PROCEEDINGS OF LOG BUCKING TECHNOLOGY SYMPOSIUM

Forintek Canada Corp.

SPECIAL PUBLICATION
NO SP-29
ISSN 0824-2119
OCTOBER 1987

JUNE 11, 1987
PRINCE GEORGE, B.C.

Proceedings of

Log Bucking Technology Symposium

June 11, 1987

Prince George, B.C.

Sponsored

by

Forintek Canada Corp.

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Western Laboratory
6620 N.W. Marine Drive
Vancouver, B.C.
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Special Publication No. SP-29
ISSN # 0824-2119
November, 1987

Table of Contents

	Page
Introduction To Computer Optimized Log Bucking Steve J. Wang, Forintek Canada Corp., Vancouver, B.C.	1- 4
True-Shape Scanning Lloyd Controls' Optimum Log Value System W.W. Thomlinson, Lloyd Controls, Port Coquitlam, B.C.	5-15
Achieving Maximum Benefits From Computer Optimized Bucking Steve J. Wang, Forintek Canada Corp., Vancouver, B.C.	16-28
Is Mixed Log Orientation In Long Log Hauling Compatible With Optimum Bucking? D.R. Giles, Forintek Canada Corp., Vancouver, B.C.	29-38
Application of "Snapshot" Scanning and Optimization to Log Bucking Leon H. Chasson, Applied Scanning Technology, Mountain View, CA.	39-47
Experience in Implementing Computer Optimized Bucking Lou Brulotte, Weyerhaeuser Canada, Ltd., Merritt, B.C.	48
Stem Optimizing: A Critical Link in Sawmill Production Control Gianni Scaramella, Mel Cruickshank Equipment Ltd., Toronto, Ont.	49-63
Bucking Optimization with "Real Shape" Scanning Paul Sullivan, Applied Theory, Corvallis, Oregon	64-75

Introduction to Computer Optimized Log Bucking

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Good morning and welcome to our symposium.

Before the symposium takes us into the details of log bucking, I would like to give some background information. This includes definitions of log bucking and merchandizing, bucking site, types of bucking systems, scope and objectives of this symposium, reasons to optimize bucking, advantages of computer optimized bucking systems, and factors affecting the performance of computer optimized bucking systems.

Definitions of Log Bucking and Merchandizing

Log bucking in a sawmill primarily refers to crosscutting of long logs into shorter segments for processing. Log bucking also involves squaring log ends, and eliminating decay, extremely crook or sweepy, or small diameter sections. Log bucking usually precedes debarking but has also been preceded by debarking. Log merchandizing includes log bucking and allocation of bucked log segments to other purposes such as logs for export or for plywood mills. From a mathematical point of view, however, log bucking is no different from log merchandizing. Therefore, what we find out about log bucking today may also apply to log merchandizing.

Bucking Site

Log bucking can take place not only at the sawmill but also in the woods. On the B.C. coast, logs are large and long. They require bucking in the woods before they can be allocated to their end processing facilities (plywood mill, sawmill, port of export, pulpmill, etc.). Further bucking is usually required at the end processing facilities. In the B.C. Interior, logs are smaller and shorter. Long log hauling is usually practised. Long logs are delivered to the mill site where they are bucked and moved to the small log mill, large log mill, or temporary storage area for other uses.

Types of Log Bucking Systems

At sawmills, there are two types of bucking systems: transverse and longitudinal. The transverse bucking system (also called sidewise bucking) consists of a series of circular saws mounted above and across an incline feed table. The logs are moved laterally (sidewise) up the incline table and crosscut by

some of the circular saws. In a longitudinal bucking system (endwise bucking), a log is moved endwise down a conveyor to a single saw for crosscutting. The single saw is usually called the cut-off saw, which can either be a circular saw or a chain saw. Sometimes two cut-off saws are used to produce two logs at once.

Both longitudinal and transverse bucking systems can be optimized by using scanner and computer technology.

Scope of This Symposium

This symposium concentrates on computer optimized log bucking at the sawmill. Bucking in the woods is not covered. The term computer optimized bucking (COB) system or autobucking system refers to a system that employs scanners to measure diameter, sweep and length of logs and uses a computer to find the optimum bucking solution for each log. The optimum bucking solution is executed either automatically by the COB system or selected by the bucking station operator for execution. This symposium will cover both transverse and longitudinal bucking systems.

Objectives of This Symposium

The objective of this symposium is to provide information on:

1. factors affecting performance of computer optimized log bucking systems,
2. system characteristics of state-of-the-art computer optimized bucking systems, and
3. advantages of computer optimized bucking systems.

The above information may provide mill managers with a sound basis for determining the needs of a computer optimized bucking system and selecting the right vendor to meet these needs.

Reasons to Optimize Bucking

The values of lumber products depend on grade, size, and length. The most important objective of log bucking is to produce log segments that will yield the highest net total long log value to the mill. Maximization of the total long log value requires the knowledge of geometric and biological conditions of the long log, products that can be produced from each log segment, costs of processing the log segments, and the prices of the lumber produced. Such a task is extremely complicated and cannot be optimized effectively by a bucking station operator without the aid of computer logic.

Recent studies indicate that average efficiency of manual bucking in the woods is only 80 percent of what is considered to be good performance (Briggs, 1980). Similar loss could be expected for manual bucking at the mill site. Such a large loss presents a great opportunity for computer optimized bucking (COB) systems. Therefore, COB systems came into being in the mid-1970's. Today, there are hundreds of COB systems in operation in the world.

Advantages of Computer Optimized Bucking Systems

The advantages include increased value or lumber recovery, improved lumber mix to meet market demands, higher productivity, accurate accounting of long log input and log segments produced in terms of volume and piece count, improved management ability to control profit, etc.

The increase in value or lumber recovery due to computerized bucking has not been well documented in North America. Unpublished private studies have shown that the increase was about three percent. Actual increase could be much higher because the operators usually performed better during mill tests when they knew their activity was under evaluation and they were usually given more time in making the bucking decisions. Additional information in this respect will be provided later by other speakers.

Every COB system provides an option to optimize on lumber value. This makes it possible to obtain desired lumber mix by changing lumber prices of various sizes and lengths.

Higher productivity of a COB system results from the rapid speed of the optimizer in arriving at the optimum bucking solutions, the automatic control of conveyor movement, log transfer, log stop, log sorting, etc. Downtimes can be easily recorded and related to causes by using the computer. This provides a means for improving preventive maintenance schedules and hence improve productivity.

A COB system usually scans each long log for diameter at fixed intervals (every two feet or smaller increments). The log length can be scanned to the nearest one inch. Accurate accounting of log input volumes can thus be achieved. Volumes and piece counts of log segments produced can be easily tabulated. If the bucking optimizer models the mill accurately, volumes of by-products such as chips, sawdust, and planer shavings can also be calculated.

Operating parameters of the COB system are usually provided by the mill management. Therefore, the operator's bucking decision is eliminated except under circumstances when operator overrides are necessary. Thus the mill management basically controls the operation of the COB system. By knowing the lumber markets, sale orders, existing log segment inventory, existing lumber inventory, the mill management can change operating parameters to maximize mill profit.

Factors Affecting the COB System Performance

The major factors that can affect the COB system performance include scanner accuracy, scan spacing or scan density, log modelling and sweep measurement, bucking optimization program, bucking rate of the system, saw spacing, log orientation, and the processing costs of log segments.

The scanner accuracy depends on the scanner type, the movement of the log during scanning, the operating environment, and maintenance and calibration of the scanner. Without accurate scanning data, the optimization program cannot arrive at the optimum bucking solution.

The more frequently the log is scanned, the better the log can be modelled. The increase in scan frequency can usually increase exponentially the computation time required to reach the optimum solution. Unfortunately, the computation time for each long log must be limited in order to achieve a

desired bucking rate. To solve the time limit problem, a preprocessing program is usually employed to smooth and simplify the scan data before bucking optimization takes place.

Log modelling and sweep measurement can affect optimum solution. Modelling logs as truncated cones without considering sweep will arrive at suboptimal bucking solutions for sweepy logs. Therefore, operators' overrides are required to improve the COB system performance. Modelling logs as end to end jointed frusta and taking sweep of the log into account should improve system performance. Modelling cross sections of logs as ellipses instead of circles may further improve performance.

The optimization program should have the capability to arrive at the optimum bucking solutions with a given time limit. Because of the time limit, the optimization program usually cannot simulate the sawing of each bucked log segment in real time. Therefore, a loook-up table which contains lumber output by size and length for logs with various characteristics is stored in the computer memory. The quality of this table has a major bearing on the bucking solution.

To achieve high bucking rate, the system's hardware (scanner, computer, etc.) must be reliable under any operating condition (temperature, dust, snow, rain, etc.).

It is generally agreed that log bucking should start from the butt end to achieve higher value or lumber recovery. The configuration of various sawing, edging, and trimming processes in the sawmill, however, could make this agreement become debatable. For example, Chip-N-Saws were found to perform better when logs were fed with butt end first. Trimming efficiency was better when the butt end of lumber was near the zero saw of a manual multiple-saw trimmer or the first saw of a manual two-saw or three-saw trimmer. Therefore, without proper arrangement of equipment in the mill, advantage in bucking from the butt end could diminish.

The processing costs of log segments must be taken into account in the optimization process. Without taking the processing costs into account, the bucking optimizer, which considers sweep, may generate too many log segments from given long logs. This would slow down productivity in many mills. The processing costs of log segments must be estimated as accurately as possible in order to achieve the optimum bucking solution.

In a computer optimized transverse bucking system, the saw spacing can also affect the system performance. Whether it should be nominally four feet or two feet needs to be determined. Saw spacing of less than two feet or more than four feet is probably not realistic.

In my second presentation today, I will discuss the effects of scanner accuracy, sweep measurement, saw spacing and processing cost on the performance of a computer optimized transverse bucking system.

Closing Remarks

I hope I have provided you with enough background to stimulate your thinking about computer optimized bucking. In closing, I would like to say that today we have four speakers representing bucking optimizer system suppliers. Their systems are among the best in North America. I encourage you to tap the knowledge of these speakers by actively asking questions.

True-Shape Scanning
Lloyd Controls' Optimum
Log Value System

W.W. Thomlinson, Lloyd Controls, Port Coquitlam, B.C.

This presentation will cover the hardware and software requirements to properly scan and optimize tree-length logs entering a sawmill. Major benefits can be realized by the mill owner. Problem logs need never enter the sawmill. Logs can be bucked to suit inventory or market demands. Increased productivity and recovery will result.

As we begin this study, let's first examine these advantages in a little more detail.

Advantages of Scanner/Computer Optimum Bucking

(Quote from Computer Controls System for Log Processing and Lumber Manufacturing by Ed Williston)

1. Log length/diameter relationship determines lumber length as well as width and thickness: therefore, to produce maximum value lumber from a given tree-length log, it is necessary to manufacture log segments at the bucking station with the proper length/diameter relationship. That can only be accomplished by use of accurate scanning equipment and a computer system to arrive at the optimum product mix, taking into account such variables as cost, selling price, order file, inventory, etc.

2. Provides management information system including:

   (a) detailed production report,

   (b) tracking of raw material flow, trim loss, shrinkage, downtime and other factors affecting recovery and efficiency,

   (c) means of measuring recovery, inventory, log allocation, planning, etc.

3. Bucking decisions are under the control of management: relieves bucking operator to monitor the overall operation of his machine centre.

Optimum Bucking System Description

Typical System Configuration

The Optimum Bucking System can be broken down into four sub-systems:

1. Scanner System

   Standard, off-the-shelf components make up the Scanner System which provides detailed information about the true shape of tree-length stems.

2. On-Line Process Control Computer and Operator Interface

   Information from the Scanner System is fed directly into the On-Line Process Control Computer which performs real-time optimum bucking solution calculations. Optimum bucking solutions are displayed (together with other relevant information) to the bucking operator via Operator Interface video screen. The computer also provides process control for automated operation of the bucking machine centre.

3. Off-Line Simulation Computer

   The Off-Line Simulation Computer allows off-line simulation of Optimum Bucking System and prepares "Log Value Table" for use by On-Line Process Control Computer.

4. Manual Back-Up System

   This typically consists of a programmable controller which provides for bucking machine centre control in the event of malfunction of the On-Line Process Control Computer.

System Description

1. Scanner System

   Lloyd Controls Limited uses two different scanner configurations for its Optimum Bucking System: longitudinal and transverse scanning. The Scanner System is designed to operate in the temperature range of -40°C to +50°C and is unaffected by ambient light.

   (a) Longitudinal Scanning

   For a typical system, the stem is transported longitudinally on a conveyor system. Located on the conveyor are photocells which are typically spaced one to two feet apart. Coupled to the conveyor system is a bi-directional encoder, which, together with the photocells, is used to measure the length of stem to a resolution of one inch. Diameter measurements are accomplished using an Opcon Series 300 type scanner (or equivalent

from another manufacturer) which consists of an array of pulsed, infra-red light-emitting diodes and an array of phototransistor detectors. Elements in the arrays are spaced to provide a diameter measurement resolution of 0.1 inch.

Typically, the diameter scanner heads are enclosed in extruded aluminum housings which in turn are housed in rugged protective steel frames for use in harsh environments.

(b) Transverse Scanning

For a typical system, the stem is transported tranversely across the photocell curtain in two axes.

The photocells in each curtain are typically spaced one to two feet apart and alternate with photocells in the other axes. Coupled to the transverse deck is a bi-directional position encoder. The photocell curtain, together with the position encoder, measures the diameter profile, length, sweep, and crook of the stem in two axes. The diameter measuring resolution is typically 0.1 inch and the length measuring resolution is typically 6 inches.

2. On-Line Process Control Computer and Bucking Operator Interface

(a) The On-Line Process Control Computer is typically a Motorola (or equivalent) 68000/68010/68020 VME bus based computer with 1 Mbyte memory. All cards in the computer use the Eurocard mechanical format (a defacto standard throughout the world). All the pin/socket connectors, card cages, and back planes meet rigid DIN and IEC standards.

(b) The On-Line Process Control Computer uses information from the Scanner System to perform real-time optimum bucking calculations:

- The values of all combinations of bucked log segments associated with each stem are determined by adding values calculated for possible individual bucked logs.
- Values for bucked logs that have sweep and/or crook are calculated from values for straight logs that are determined to be of equivalent value, with an adjustment for the value of any additional yield of chips.
- Values for straight logs of various small-end diameters, length and tapers, in excess of their values as chips, are obtained from a prepared "Log Value Table".
- The combination of bucked log segments which maximize the value of the stem is the optimum bucking solution.

(c) The optimum bucking solution is displayed to the bucking operator via the Bucking Operator Interface which typically consists of a video monitor and a bucking operator console. Besides diplaying the optimum bucking solution, the Bucking Operator Interface also provides the following features:

- Annunciates alarm conditions associated with the system.

- Allows operator to override the optimum bucking solution because of stem defects (such as rot, split, shake, etc.).

- Process control associated with bucking process.

(d) Standard features associated with Optimum Bucking System:

- Continuous self-diagnostic on Scanner System and other hardware associated with the system, annunciating alarm conditions to Bucking Operator Interface.

- Transfer of stem data file from On-Line Process Control Computer to Off-Line Simulation Computer for analysis.

- Reports available include stem tally, bucked log segments tally, projected recovery in terms of dollar value, total input volume.

- Detailed profile display of individual stems after being scanned.

3. Off-Line Simulation Computer
Connected to the On-Line Process Control Computer is an Off-Line Simulation Computer the functions of which are as follows:

(a) Compute rough, green lumber values; based on finishing lumber prices, grade yields and finishing cost.

(b) Generate lumber lists and piece counts for straight, uniformly tapered logs of each small-end diameter, length and taper class, optimized for given rough, green lumber values and incremental machine costs.

(c) Generate "Log Value Tables" for downloading to On-Line Process Control Computer.

(d) Receive "Stem Data File" from On-Line Process Control Computer.

(e) Perform off-line bucking simulation based on "Stem Data File". This feature allows management direct control over product mixes that will be produced.

(f) The following are some of the parameters that can be changed:

- Lumber target sizes, including minimum, maximum, target, finished, shrinkage, planing allowance.

- Sawmill machine data (specific for each individual mill) including types, saw kerf, sawing variation, speed, etc.

- By-product prices including chips, sawdust, etc.

- Lumber price table.

4. Manual Back-Up System

The system is designed to operate in a semi-automatic mode in case of scanner or computer failure. All computer-controlled machine functions of the system are duplicated in a back-up programmable controller system.

General System Layout and Operation

The following describes the general layout of the Log Merchandizing System and the operational sequences as controlled by the computer.

1. Each tree-length log (up to 80 feet in length) is manually loaded and singulated from the infeed deck onto No.1 roll case (Figure 1). Under normal conditions, all logs are aligned so that the butt-ends are closer to the log line.

2. The log moves longitudinally on No.1 roll case towards the log line. The bucking operator can energize any one of the five end stops (located at nominal 8, 16, 24, 40 and 56 feet from the log line) while the log is on the No.1 roll case.

3. The tree-length log moves transversely up the scan deck into the diameter and length sensing zone.

   (a) The diameter sensing zone consists of 81 photoelectric cells (located approximately three lug spaces downstream of No.1 roll case) spaced approximately one foot apart. The 81 cells are located in two planes (X plane and Y plane, which are approximately 60 degrees from each other). The X plane consists of 41 cells spaced approximately two feet apart (starting at the log line). The Y plane consists of 40 cells spaced approximately two feet apart (starting at one foot from the log line).

   The two planes of photocells, together with an encoder mounted on the scan deck, are used to arrive at the tree-length log diameter profile, crook and sweep in two directions.

   (b) The length sensing zone consists of 50 photoelectric cells, which, together with the encoder mounted on the scan deck, are used to arrive at the approximate length of the tree-length log.

4. The optimum bucking solution of the tree-length log is then determined (refer to next section).

5. After scanning, the tree-length log is dropped onto No.2 roll case where there will be a longitudinal movement to another end-stop (located at nominal 0, 16, 24, 32, 40 and 56 feet from the log line). The computer will energize the appropriate end-stops if required: otherwise the tree-length log will travel towards the log line. The computer will also reverse No.2 roll case if either the 40 foot or the 56 foot end-stop is to be energized (described below).

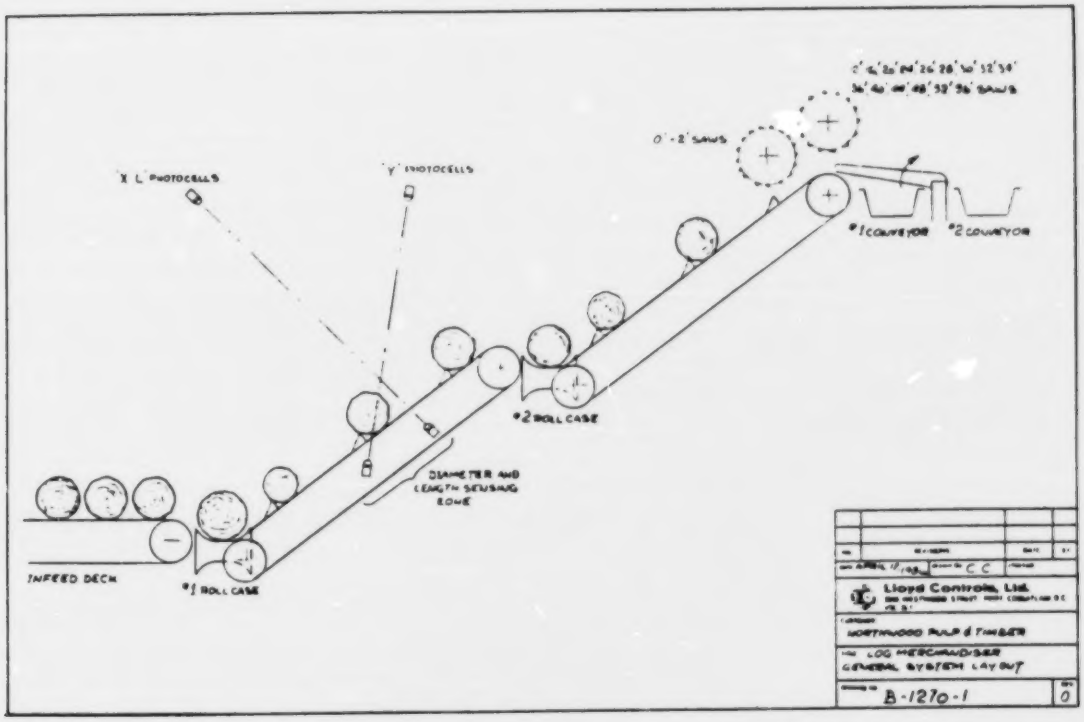

Figure 1: Cross-sectional view of the Log Merchandizing System.

6. System will also display the following information via the bucking operator console when tree-length log arrives at No.2 roll case:

   (a) Saws to be energized (to reflect optimum bucking solution) for the tree-length log that is in No.2 roll case. This is designated the "decision lug". The number of the outfeed drop gates (up to four) for either outfeed conveyor No.1 or No.2 will also be displayed.

   (b) The second and third rows of Saw Select Echo and the number of outfeed drop gates for the second logs downstream of the "decision lug" is also updated.

   (c) Oversize log (if over 32 inches in diameter).

7. The bucking operator is also provided with a 14 inch video monitor showing the following information:

   (a) Snapshot (length, butt and top diameter of tree-length log, bucking solution, projected dollar value, saws to be energized, bumper on No.2 roll case to be energized) for tree-length log in No.2 roll case.

   (b) Oversize log information (including length of oversize to be bucked off).

   (c) Flashing error messages (indicating problems).

8. While the tree-length log is still in No.2 roll case, the bucking operator could override the optimum bucking solution (displayed in the first row of Saw Select). This could be accomplished as follows:

   (a) Operator depresses appropriate Saw Select buttons (first Saw Select button that the operator entered should clear the computer-selected solutions from the Saw Echo) to reflect his override decision.

   (b) If operator decides to cancel the Saw Select (that he has just entered), he could depress CANCEL and the original computer-selected solutions will reappear in the first row of Saw Echo.

9. Besides the log in No.2 roll case, the operator could also override the computer-selected optimum bucking solutions for the two logs downstream of No.2 roll case (the whole process of override must occur while the three rows of Saw Select Echo are not changing). This could be accomplished as follows:

   (a) Operator depresses apropriate Saw Select buttons (the first Saw Select button that the operator entered should clear the computer-selected solutions from the first row of Saw Echo) to reflect his override decision.

   (b) Operator then shifts the decisions downstream by energizing Shift Queue (to override the log that is one or two lugs downstream of "decision lug"). The Saw Echo for unaffected logs should reappear after the manual decision goes past itself.

(c) If operator decides to cancel the Saw Select (that he has just entered) he could depress CANCEL (must be before energizing Shift Queue) and the original computer-selected solutions will reappear in the first row of Saw Echo.

10. After the optimum bucking solution is arrived at and if the first cut (as measured from the log line end) is either 14, 18 or 22 feet, the computer also energizes the 2-foot, 1/2-inch, moveable bumper (located between No.2 roll case and oversize roll case) before the log drops into No.2 roll case.

11. When tree-length log arrives at bucking saw zone, appropriate saws are energized to reflect the proper bucking solutions (computer or manual selection). Saw limit switches are monitored to ensure that appropriate saws are energized. SAW FAULT indicator is energized to indicate a saw fault condition; simultaneously, slasher deck drive is stopped. Depressing SAW FAULT reset will turn off SAW FAULT indicator and reenable slasher deck drive.

12. The bucked short logs associated with each long log are to be diverted alternately to No.1 and No.2 conveyor.

13. Tree-length logs that are over 32 inches in diameter are classified as oversize logs and should be processed to cut off parts or all of it so that no part of the remaining log is over 32 inches (logs over 32 inches would physically jam up the system downstream of slasher deck). Oversize logs are processed as follows:

(a) Computer detects logs over 32 inches in diameter and turns on Oversize Echo to inform the bucking operator. Simultaneously, the video monitor will also indicate the total length of the oversize portion that needs to be cut off.

(b) As soon as computer detects that oversize log has dropped into No.2 roll case, it will disable slasher deck drive and thus stop log's movement up the slasher deck.

(c) At this point, the operation to cut off the oversize portion is controlled by operator.

i) Operator selects Oversize Bumper (12 or 16 foot); programmable logic controller (PLC) energizes appropriate oversize bumpers.

ii) When log reaches oversize bumper, operator makes oversize cut; he stops No.2 roll case and deenergizes oversize bumper so that the first piece of oversize log will travel towards far end of oversize roll case and get kicked off.

iii) If oversize portion is over 16 feet, operator repeats procedure until oversize portion is completely cut off, at which point operator energizes OVERSIZE LOG PUSHBUTTON to inform computer that oversize operation is finished.

(d) Computer now reenables slasher deck drive to allow normal processing to occur.

14. If log (diameter of which is less than 32 inches) enters merchandizer with butt the wrong way (that is, away from log line), it is to be treated as follows:

    (a) Computer will reverse No.2 roll case (after previous log has left No.2 roll case but before the affected log drops in).

    (b) If far end (in this case the butt end) of log does not extend beyond the 40 foot bumper (on No.2 roll case) computer will bring up the 40 foot end-stop (in order to run the log to the 40 foot end-stop). The bucking solution will then be referenced to the 40 foot end-stop.

    (c) If far end of log extends beyond the 40 foot end-stop but not the 56 foot end-stop, computer will bring up the 56 foot end-stop (in order to run the log to the 56 foot end-stop). The bucking solution will then be referenced from the 56 foot end-stop.

15. If log enters the merchandizer with butt the wrong way and is also oversized (over 32 inches) then the whole log has to be cut up (manually by the operator) and sent out through the oversize roll case. The procedure is similar to the procedure described in Item 13 above.

16. It is possible that no bucking solution is arrived at for a tree-length log. In this case, the slasher deck drive is disabled, OVERSIZE indicator turns on and the message "NO BUCKING SOLUTION" appears on the video monitor. Operator should manually enter a solution (see Item 8). Depressing OVERSIZE pushbutton will turn off OVERSIZE indicator and reenable slasher deck drive.

17. Management reports and various diagnostic programs are available via the computer terminal.

18. An IBM PC (located in the sawmill office) communicates with the on-line process control computer:

    (a) Optimum Bucking Solution Log Price Table (see next section) is transferred from the IBM PC to the On-Line Process Control Computer.

    (b) On request, the On-Line Process Control Computer transfers detailed tree-length profile information to the IBM PC.

    The communication must take place when the on-line process control computer is idle.

On-Line Bucking Optimization Program

The following section briefly describes the on-line bucking Optimization Algorithm.

a) If the operator has selected an end-stop in the No. 1 Roll Case, its number is determined. Otherwise, the end-stop near the log line is assumed.

b) The information from the scanning system is analyzed. If a cell appears to be permanently blocked or unblocked, data from this cell is ignored. All the cell data are also filtered to reject flickering cells.

c) The limits of the longitudinal position of the tree-length log at each end are determined from the scan data. These are compared to the position of the selected end-stop. If the end of the stem appears to be beyond the stop, data on the end-stop position is ignored. If the scan data is consistent with the stem being against the end-stop, the stem is assumed to be against the end-stop. Otherwise, the end of the stem is assumed to be midway between adjacent blocked and unblocked scanning cells. In this way, the estimated, minimum and maximum possible stems lengths are determined.

d) The stem diameters at the scanning locations are searched to determine which is the large end, and if any portion of the stem is oversize. If the stem is oversize at the end farthest from the zero line, the whole stem is reported as oversize and the procedure stops. Otherwise a table of permissable oversize log lengths is searched and one of these lengths, plus any butt-trim requirement input by the operator, plus kerf, sufficient in total to remove any oversize material, is assumed to be removed by the oversize saw. If oversize material is removed, the remaining stem is assumed always to be positioned against the adjustable stop near the log line.

e) The program then selects an appropriate stop in the No. 2 Roll Case and assumes that the stem will be moved up to this stop.

f) The program interpolates between data generated at the scan locations to determine the diameters and positions of the stem cross sections at the average of possible bucking saw locations relative to the end of the stem. This end may be against the adjustable end-stop or one of the other fixed stops.

g) The program then determines which combination of permissable bucking saws and end-stop positions will maximize the value of the stem.

It does this by determining the values of all combinations of bucked log lengths that could yield an acceptable optimum solution, by adding values calculated for possible individual bucked logs. Values for bucked logs that will have crook or sweep are calculated from values for straight logs that are determined to be of equivalent value, with an adjustment for the value of any additional yield of chips. Values for straight logs of various small-end diameters, lengths and tapers, in excess of their values as chips, are obtained from a pre-prepared Log Price Table Files. The Log Price Table file is generated off-line on an IBM PC.

h) The program accepts restrictions on sawlog lengths, and the diameter and length of any pieces that are bucked to less than sawlog length.

i) Since the stem length may not be known precisely, the length of the last bucked log may not be known precisely. The most probable stem length is used to determine the optimum, subject to restrictions that the maximum possible length of the last log shall not exceed a given maximum length, and that the last log will not be valued as a sawlog if its minimum possible length is shorter than the minimum length for a sawlog.

j) A piece that is too short to be a sawlog, or whose small-end diameter is too small for a sawlog, will be assumed to be debarked and valued as chips if it is not less than a minimum diameter and length for debarking, specified in the input data. Otherwise it will be assumed to be a residual piece, that it will not be debarked, and will be given another value that may be specified in the input data. A residual piece will not be produced, but will instead be left on the last log if possible, if its diameter or length exceeds maxima specified in the input data. By choosing appropriate values for input data, production of pieces of less than sawlog length can be controlled. By setting the maximum diameter and length for residual pieces to zero, production of residual pieces can be prevented.

k) The value of sawlogs and logs to be debarked and chipped can be reduced by including processing costs for the sawmill and debarkers in the input data. These costs are assumed to be the sum of a constant cost per piece plus a cost per unit of log length. If processing costs are included, there will be a tendency to process fewer, longer logs on average, and to produce more residual pieces at the expense of sawlogs. The correct costs to use will depend, among other things, on the spare capacity, if any, in the sawmill and finishing processes.

Achieving Maximum Benefits From Computer Optimized Bucking

Steve J. Wang, Forintek Canada Corp., Vancouver, B.C.

Introduction

The application of computer optimized bucking (COB) to North American sawmills began in the mid-1970's. The early COB systems usually measured diameter and length of long logs with poor accuracy and did not measure sweep. Over time, COB technology has advanced. Today, COB bucking systems not only can measure diameter and length much more accurately but also can measure sweep in one, two or even three planes. The frequency of diameter scan along the length of the log has also been increased.

The advances in bucking technology have made mill managers much more aware of the need of COB systems. Consequently, installation of COB systems has become the top priority of many mill managers. The cost of a COB system can vary greatly depending on the type of scanner and the system configuration. Factors such as scanner accuracy, scan frequency, sweep measurement, and saw spacing can affect total system cost significantly. As I pointed out in my previous presentation, these factors can affect system performance. Without knowing the magnitudes of the effects of these factors on system performance, mill managers may find it difficult to select the right COB system configuration and supplier.

Processing costs of log segments can affect bucking solutions of the COB system and hence also affect mill profit. Without understanding of the impact of processing costs on bucking solution, mill profit may be negatively affected if the processing costs are ignored or not properly set.

Objectives

The objectives of this study were to determine the effects of sweep measurement, scanner accuracy, saw spacing, and processing costs on the performance of a computer optimized transverse bucking system (COTB). Results from this study will assist mill managers in configuring and operating COB systems.

Approach

To accomplish the objectives, simulation was deemed to be the most appropriate approach and was adopted in this study. SAWSIM (Leach, 1979), a log bucking and sawing simulation program, was chosen as the simulation tool.

In order to obtain realistic simulation results, an existing COTB system was modelled. In addition, real log data were used. The existing COTB system and the log data collection procedure are described below.

The Computer Optimized Transverse Bucking Systems

The COTB system had 60 one-foot spaced photocells across an incline deck to measure sweep and diameters of the long log. The photocells were aimed perpendicularly to the incline deck surface. Thus only diameter and sweep in the incline deck plane were measured. The saws were about 4-foot spaced starting from the zero saw (0,4,8,...,60). A -2 saw was also present. A variable bumper controlled the positions of the log ends. Thus the system normally produced log segments that were multiples of four feet. The first log segment could be produced as a multiple of two feet by moving the bumper back (away from the zero saw) by two feet and utilizing the -2 saw. The minimum distance between the bumper and the zero saw was 2-1/8 inches, resulting in a minimum end trim of 2-1/8 inches for all logs. The operator's responsibility was to singulate the long logs and control the bumper for squaring log ends. The COTB system could buck the logs with sweep either considered or not. Most logs were bucked with the butt ends near the zero saw. Occasionally there were logs bucked with the top ends near the zero saw. The logs were debarked after being bucked.

The system maximized lumber value with three restrictions: 1) if the long log length was more than 20 feet, the first log segment had to be 12 feet or longer; 2) a $1.25 processing cost was applied to each log segment; 3) the system could not slash a section that was longer than four feet.

Procedure

The study procedure consisted of two parts: log data collection and log bucking and sawing simulation.

Log Data Collection

Fifty sound long logs were randomly selected from the study mill. All logs had reasonably square butt ends. The distribution of the logs by diameter and length is shown in Figure 1.

The selected logs were laid on skids on the log yard. Diameter and sweep measurements (usually outside bark unless bark was removed during transportation and handling) were taken at two perpendicular directions, at approximately every two feet along the length of each log. Care was taken to measure diameter and sweep at locations where sweep changed noticeably but not at knotty locations. The

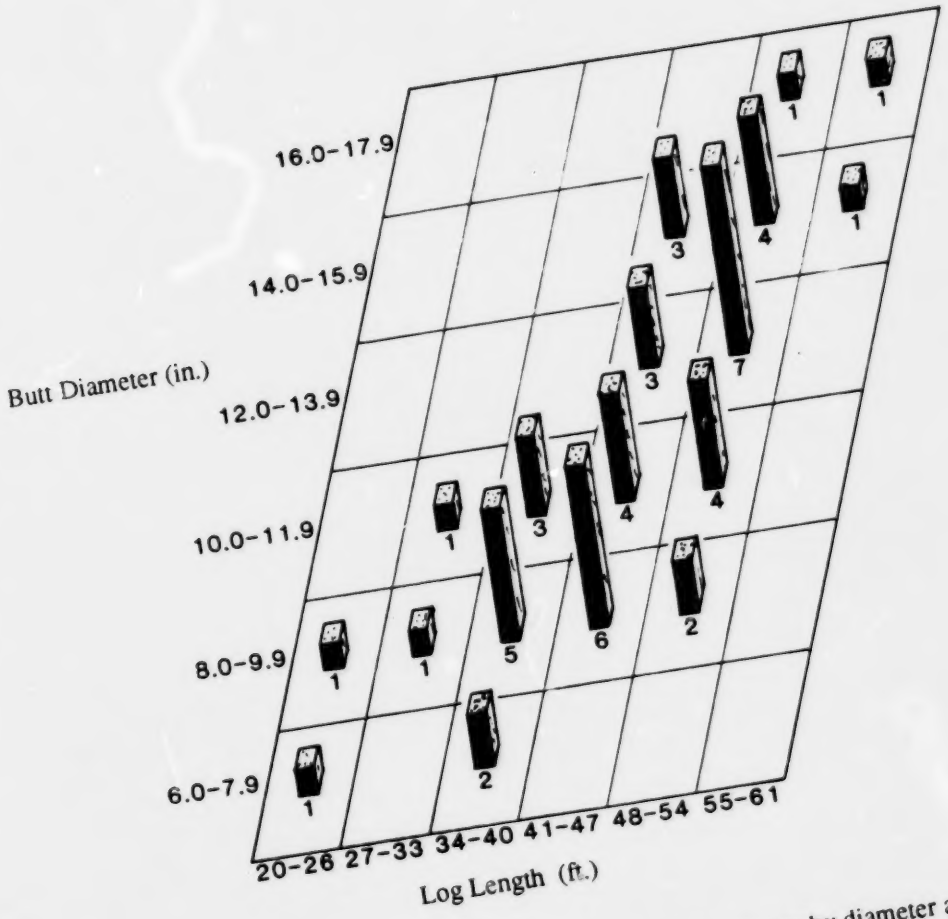

Figure 1: Distribution of sample logs for the transverse bucking system by diameter and length.

diameter and sweep measurements were read to the nearest 0.01 inch. Presence or absence of bark at the four points where the caliper blades touched the log was recorded. The length of each log was measured to the nearest 1/8 inch with a measuring tape.

The equipment for taking the measurements included a transit, outside calipers (with 0.1 inch division), and a 36 x 36-inch plywood (with 12-inch square removed from one corner) on which waterproof, high accuracy one-inch grid paper was overlaid. Figure 2 shows the set-up for measuring diameter and sweep.

After the diameter, sweep, and length measurements, the logs were bucked by the COTB system and the resulting log segments were measured for bark thickness. For the first log segment, bark thickness was measured at the butt end, four feet from the butt end, and the small end. For the rest of the log segments, bark thickness was measured only at the small end of the segment. Four measurements were taken at each location. The average of the four bark thicknesses was used to adjust diameter and sweep measurements. Bark thickness was estimated by interpolation for all other data points.

Log Bucking and Sawing Simulation

In SAWSIM (Leach, 1979), logs were modelled as end to end jointed frusta. A graphical representation of a long log is shown in Figure 3.

In the SAWSIM model of the mill, actual mill layout, target sizes, and saw kerfs were used. Lumber prices used at the time of log data collection were also used. The exact saw locations of the COTB system were also used. All SAWSIM runs for this study were made by Bradley J. Turner of Carroll Hatch (International) Ltd.

To achieve the objectives, several sets of SAWSIM runs were made.

Sweep Measurement, Scanner Accuracy, and Processing Costs

To study the effects of sweep measurement, scanner accuracy, and processing costs on the performance of COTB system, SAWSIM was used to optimum-buck the logs. Four sets of SAWSIM runs were made. The first set assumed that the scanner was perfectly accurate and had the same operating restrictions as those placed on the COTB system. The second set also assumed that the scanner was perfectly accurate and did not have the restrictions that were placed on the COTB system. The third set assumed that the scanner accuracy was 0.15 inch and had the same restrictions as those placed on the COTB system. The scanner accuracy was simulated by adjusting the diameter and sweep measurements with random numbers which were normally distributed with mean zero and standard deviation 0.15 inch. The fourth set was the same as the third except that 0.25 inch scanner accuracy was assumed instead of 0.15 inch.

For each set, there were four SAWSIM runs. The first run of each set simulated the COTB system without considering sweep and is denoted by NS (No Sweep) in Tables 1 and 4. In the second run of each set, logs were oriented as measured and only the sweep in the vertical direction was considered for bucking (horizontal sweep was set to zero). These runs are denoted as VS in Tables 1 and 4. In the third

Figure 2: Set-up for measuring diameter and sweep of logs.

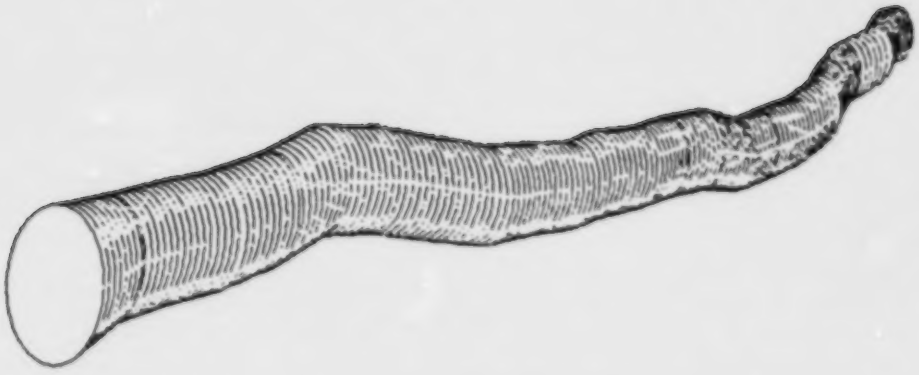

Figure 3: Log modelled as end to end jointed frusta in SAWSIM.

run of each set the logs were rotated with horns sideways and then only the sweep in the horizontal direction was considered for bucking (sweep in vertical plane was set to zero). These runs are denoted by HS in Table 1. In the fourth run (denoted as TPS in Tables 1 and 4), sweep in both vertical and horizontal directions was considered.

Saw Spacing

The saws of the COTB system were approximately four feet spaced, except the zero saw and the -2 feet saw. In order to study the effect of saw spacing, the nominal four feet spacing was reduced to two feet. With this the only difference, the fourth run of the first, second and third sets was repeated.

Results and Discussion

Even though the study was conducted with a COTB system model, the results are equally applicable to a computer optimized longitudinal bucking system, except for the results on saw spacing. The results are discussed below.

Effect of Sweep Measurement on the COTB System Performance

Results of four sets of SAWSIM runs are summarized in Table 1. There were two single plane sweep SAWSIM runs (VS and HS) in each set. The results of VS and HS runs were similar. Since no attempt was made to rotate the maximum sweep to a given direction, the sweep rotation in the VS runs was believed to approximate the real situation better. Therefore the results from the VS runs were used to calculate percent value increase due to sweep measurement (Table 3).

The first set results show that measuring sweep in one plane increases value recovery from 51.8 for no sweep measurement to 53.7 dollars per cubic meter (Table 1) or 3.7 percent increase (Table 3). The improvement for two plane sweep measurements was 7.3 percent. Bucking efficiency (expressed as percent of the value recovery of the TPS run of the first set) improved from 93.2 percent for no sweep measurement to 96.6 percent for measuring sweep in one plane, and 100 percent for measuring sweep in two planes (Table 2). The results of the second set of SAWSIM runs are not included in Table 2 and will be discussed later.

In the third set, value recovery was improved by 2.7 percent and 4.4 percent for single plane and two plane sweep measurements, respectively. Bucking efficiency improved from 93.2 percent for no sweep measurement, to 95.7 percent and 97.3 percent for single plane and two plane sweep measurements, respectively (second set in Table 2).

In the fourth set, value recovery was improved by 2.5 percent and 2.7 percent for single plane and two plane sweep measurements, respectively. The bucking efficiencies for no sweep, single plane sweep and two plane sweep measurement were 93.7, 96.0 and 96.2 percent respectively (third set in Table 2). The

Table 1

Summary of SAWSIM Optimized Lumber and Value Recoveries of the Transverse Bucking System with Various Characteristics

Scanner Accuracy (in.)	Sweep Option	Saw Spacing (ft.)	Processing Cost ($/log)	Lumber Recovery (bf/m^3)	Value Recovery ($/$m^3$)	Number of Log Segment
0	NS*	4	1.25	257.7	51.8	128
0	VS*	4	1.25	270.3	53.7	140
0	HS*	4	1.25	269.3	53.7	138
0	TPS*	4	1.25	277.7	55.6	140
0	NS	4	0	262.6	52.2	142
0	VS	4	0	273.2	54.0	147
0	HS	4	0	274.7	54.3	145
0	TPS	4	0	288.6	56.4	161
0.15	NS	4	1.25	257.8	51.8	129
0.15	VS	4	1.25	267.4	53.2	142
0.15	HS	4	1.25	268.9	53.5	138
0.15	TPS	4	1.25	273.6	54.1	141
0.25	NS	4	1.25	259.6	52.1	130
0.25	VS	4	1.25	268.9	53.4	141
0.25	HS	4	1.25	266.2	53.1	140
0.25	TPS	4	1.25	269.8	53.5	139
0	TPS	2	1.25	281.9	56.2	144
0.15	TPS	2	1.25	277.5	54.9	145
0.25	TPS	2	1.25	272.1	53.8	143

* NS = Sweep was not considered in the simulation, i.e., stems were treated as truncated cones in the simulation;
VS = Stems were oriented as measured and lonly the vertical sweep was considered in the simulation;
HS = Stems were oriented with horns sideways (in the horizontal plane) and only the horizontal sweep was considered in the simulation;
TPS = Both vertical and horizontal sweeps were considered in the simulation.

Table 2

Bucking Efficiencies of Various Computer Optimized Transverse Bucking Systems

Scanner Accuracy (in.)	Sweep Option	Saw Spacing (ft.)	Processing Cost ($/log)	Bucking Efficiency (%)	Number of Log Segment
0	NS**	4	1.25	93.2*	128
0	VS**	4	1.25	96.6	140
0	HS**	4	1.25	96.6	138
0	TPS**	4	1.25	100.0	140
0.15	NS	4	1.25	93.2	129
0.15	VS	4	1.25	95.7	142
0.15	HS	4	1.25	96.2	138
0.15	TPS	4	1.25	97.3	141
0.25	NS	4	1.25	93.7	130
0.25	VS	4	1.25	96.0	141
0.25	HS	4	1.25	95.5	140
0.25	TPS	4	1.25	96.2	139

* Bucking efficiency is expressed as a percent of optimum value recovery of the TPS Run with perfect scanner accuracy, four-foot saw spacing, and $1.25 processing cost.

** NS = Sweep was not considered in the simulation, i.e., stems were treated as truncated cones in the simulation;
VS = Stems were oriented as measured and lonly the vertical sweep was considered in the simulation;
HS = Stems were oriented with horns sideways (in the horizontal plane) and only the horizontal sweep was considered in the simulation;
TPS = Both vertical and horizontal sweeps were considered in the simulation.

Table 3

Effect of Sweep on Value Recovery of SAWSIM Optimized Transverse Bucking System for Three Sets of Operating Conditions

Scanner Accuracy (in.)	Saw Spacing (ft.)	Processing Cost ($/log)	% Value Recovery Increase Over No-Sweep Option	
			Single Plane Sweep	Two Plane Sweep
0	4	1.25	3.7	7.3
0	4	0	3.4	8.0
0.15	4	1.25	2.7	4.4
0.25	4	1.25	2.5	2.7

Table 4

Effect of Scanner Accuracy on Value Recovery of SAWSIM Optimized Transverse Bucking System

Sweep Option	Saw Spacing (ft.)	Processing Cost ($/log)	% Value Recovery Change	
			Scanner Accuracy	
			0.15 inch	0.25 inch
NS	4	1.25	0	+0.6
VS	4	1.25	-0.9	-0.6
TPS	4	1.25	-2.7	-3.8

improvements shown by the third and fourth sets were substantially less than those shown in the first two sets. These results show that the benefits of sweep measurement decreased when the scanning error increased. Thus, to reap the full benefits of sweep scanning, the diameter and sweep scanner should be as accurate as possible.

Effect of Scanner Accuracy on the COTB System Performance

Table 4 summarizes the effect of scanner accuracy on value recovery. When sweep was not considered in optimum bucking, the 0.15 inch scanner accuracy had no effect on value recovery, while the 0.25 inch scanner accuracy increased the value recovery by 0.6 percent, which could be considered insignificant. Thus, it can be concluded that for optimum bucking without considering sweep, there is no advantage in improving the scanner accuracy of 0.25 inch.

When single plane sweep was considered in optimum bucking, 0.15 and 0.25 inch scanner accuracies resulted in 0.9 and 0.6 percent value recovery losses respectively. These losses are considered marginal. Thus we may consider that 0.2 inch scanner accuracy is adequate for measuring sweep in one plane.

When sweep in two planes was considered in optimum bucking, the value recovery losses were 2.7 percent and 3.8 percent for 0.15 and 0.25 inch scanner accuracy respectively. These are significant losses. Thus, to realize the major benefits of optimum buckng considering sweep in two planes, the scanner accuracy should be better than 0.15 inch.

The above discussion of scanner accuracy assumed that the diameter and sweep measurements were not affected by the presence of bark at the points of measurements. This is not true in many existing COB systems, since bucking is usually done ahead of debarking. Therefore, the diameter and sweep, as measured by the scanner, need to be corrected for bark thickness to adjust to inside bark diameter and sweep. Bark thickness is usually based on diameter and stored in the COB system computer. Since bark thickness does not have a perfect relationship with diameter, the adjusted diameter and sweep are subject to more error in addition to that of the scanner. The error can be further worsened when bark is accidentally removed during transportation and handling prior to bucking. Therefore, for the same bucking efficiency , bucking before debarking will require better scanner accuracy than bucking after debarking.

Effect of Processing Cost on the COTB System Performance

The optimum bucking solution of a long log depends on the COB system parameters such as lumber prices, target sizes, saw kerfs, processing costs, etc. Therefore, when these parameters change their values in real situation, they should also be revised accordingly for the COB system. Only the impact of processing cost per log segment on bucking solution was studied here.

The second set results in Table 1 were obtained with a zero processing cost. For the same sweep option, the value recovery obtained with the zero processing cost was always greater than that obtained with the

$1.25 per log processing cost. These increases were accompanied by much larger percent increases in the numbers of log segments. For example, for the NS option, the value recovery from $1.25 processing cost was $51.8 per cubic metre and that from zero processing cost was $52.2, an increase of 0.8 percent. The increase was accompanied by an 11 percent increase in the number of log segments (128 vs 142). The increase in piece count can reduce productivity significantly if the sawmill is constrained at some point downstream from log bucking. Therefore it is important that the processing cost of a log segment is accurately determined.

Effect of Saw Spacing on the COTB System Performance

Only three additional SAWSIM runs were made to study the impact of saw spacing on the COTB system performance. In these runs, nominal two-foot spacing was used, the scanner was assumed to have an accuracy of 0, 0.15, and 0.25 inch, respectively, the processing cost per log was $1.25, and SAWSIM optimum bucking considered sweep in two planes. SAWSIM results are shown in Table 1. Comparing the results of the run with 0.15 inch scanner accuracy to those of a similar run with four-foot saw spacing, we see that the lumber recovery was increased by 1.4 percent (277.5 vs. 273.6), value recovery was increased by 1.5 percent (54.9 vs 54.1 $/m), and the number of log segments was increased by 2.8 percent (145 vs. 141).

Comparing the results of the run with 0.25 inch scanner accuracy to those of a similar run with four-foot saw spacing, we see that the value recovery was increased by only 0.6 percent (53.8 vs. 53.5), which is considered insignificant.

These results indicate that for optimum bucking considering sweep in two planes, the two-foot saw spacing is better than four-foot, if the scanner accuracy is 0.15 inch or better. The advantage diminished to essentially none when the scanner accuracy worsened to 0.25 inch.

Conclusions

Scanning sweep in two planes with perfect scanning accuracy was found to improve computer optimized bucking efficiency by up to eight percent. For one plane sweep scanning, this uplift was reduced to four percent.

A scanner accuracy of at least 0.15 inch is necessary to realize the major benefits of sweep scanning in two planes. This requirement is reduced to 0.25 inch for sweep scanning in one plane.

Most sawmills are "piece count" constrained at some point downstream from log bucking. Therefore, any significant increase in the number of logs generated during bucking will negatively affect productivity and overall mill efficiency. Unrestrained computer optimized bucking usually increases the number of logs generated and this impact must be included in the optimization routine.

Reduction of saw spacing from nominal four feet to two feet can increase value recovery by 1.5 percent if diameter scanning accuracy is better than 0.15 inch. The increase diminishes when the scanner accuracy decreases and/or a single plane sweep is used.

The above conclusions are based on the assumption that debarking takes place before bucking. Most existing COB systems buck the logs before debarking. The effect of bark can incrase scanner error by up to 0.3 inch depending on the tree species, diameter, and how long logs are stored or handled. Therefore, bark effect must be included in the estimation of scanner accuracy.

Reference

Leach, H.A. 1979. SAWSIM: Sawmill Simulation Program. H.A. Leach and Company Ltd., Vancouver, B.C.

Is Mixed Log Orientation In Long Log Hauling Compatible With Optimum Bucking?

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Introduction

A joint field study, involving Forest Engineering Research Institute of Canada (FERIC), Forintek and Crestbrook Forest Industries Ltd., to identify the costs and benefits of log hauling options on sawmill performance was carried out in Cranbrook. Forintek participated in this project, by designing, coordinating and analyzing the results of a sawmill study. This study was designed to provide valuable information on primary breakdown and trimming performance, as a result of butt and top-end feeding. This information will help formulate bucking and sorting strategies for improved sawmill performance.

FERIC has been studying log transportation, including load weights, bunk spacing, axle distribution, use of trailers, and long log (up to 20 metres) hauling. Increased log lengths will reduce delivered log costs, but may increase manufacturing costs at the mill. This increase may be offset, however, by an increase in the utilization options available to the mill, resulting in increased overall profitability. Mixing butts forward and back during log hauling may lower delivered log costs, but increased breakage in the mill yard is experienced when stems are handled by the top end. Optimum log orientation for feeding primary breakdown equipment is much debated; however, most sawmill operators agree that logs should be bucked from the large end, and lumber trimmed butt-end first in a two-saw trimmer operation. Most sawmills are designed and operate more efficiently when all logs are oriented the same way on the infeed deck.

Objective

The objective of the sawmill test was to determine the difference in bucking, recovery and trimming performance, at the sawmill, due to log orientation on the infeed deck. The results of this sawmill study will be included in the economic analysis for the total project.

The project objective was to evaluate the economics (from stump to greenchain) of mixing butts forward and back on highway log trucks for maximum payload.

Project Description

The project involved several phases to obtain information on hauling, mill yard sorting, and sawmill processing of mixed loads. The phases were:

1) Evaluation of current axle load distributions for logging trucks with all butts forward (weight scale sample).

2) Evaluation of current loading and skidding productivities for the equipment producing butts forward truck loads (landing observations and detailed timing).

3) Evaluation of millyard productivity for knuckle boom and front-end loaders while piling and forwarding logs to the sawmill infeed with all butts forward.

4) Development of optimum loading strategies for optimum axle loading with butts forward and back.

5) Documentation of sawmill efficiency and recovery for butt versus top forward log orientation.

6) Evaluation of skidding, loading, millyard, and sawmill production resulting from the mixed loading concept.

7) Investigation and evaluation of options to handle mixed loads in the millyard and on the sawmill infeed deck.

Results and discussion of the sawmill test phase are reported here.

Procedures

Ten truckloads of logs from a pine stratum were selected, scaled, and pencil-bucked for highest lumber recovery. A qualified log scaler and experienced bucking operator from the mill assisted in the process. One load was excluded because of different species content and average piece size. Two groups of four loads each were selected to give similar volume, piece size and expected recovery totals. The remaining load was abandoned. Larch stems were scaled and then separated from the test logs to avoid mixed lumber types in the mill. All logs in each load were oriented in one direction; however, the original orientation was noted on the scale sheets. Table 1 gives details on individual loads and the combined groups. A coin toss determined which group would be run butt-first through the mill.

Logs with diameters (including butt swell) exceeding 35 cm (14 in.) were processed as headrig logs. Single headrig sawlogs were bucked in the mill yard and separated from the smaller end of the stem. If two logs were designated as headrig size, the entire stem was usually allocated to the headrig side.

Sawmill testing was completed on a Saturday to ensure exclusion of non-test lumber. Loads were processed separately, by orientation class. Actual bucking solutions, decided by the same operator who had determined the pencil-bucking solutions, were recorded, by noting the stop(s) used for bucking the short logs and measuring the final log segment for each stem. Logs on the headrig side were measured

Table 1

Truckload Summaries for Sawmill Test Data

Orientation	Load	Stems	Short Logs		Volume (m^3)	Avg. Diameter (cm)
			Head	CNS		
Butts Ahead	1	78	11	184	35.3	19.1
	5	76	8	170	29.8	18.2
	7	94	13	174	34.7	19.6
	9	104	15	195	33.9	18.9
		352	47	723	133.7	18.9
Tops Ahead	2	81	10	179	35.1	19.1
	4	93	7	217	37.7	18.2
	6	94	12	204	36.2	18.2
	10	76	19	126	27.2	20.0
		344	48	726	136.2	18.8

for length, after bucking, on the infeed deck before processing. Logs were processed through the Chip-N-Saw or headrig and secondary machine centres, then pencil-trimmed, by quality control supervisors, processed through the trimmer and tallied at the J-bar. Lumber from each load was tallied and sorted separately. The J-bar reject sort for each load was pencil-tallied and included in the lumber total for that load.

Log breakage, mill waste and chip production were estimated for each orientation class.

In the laboratory analysis, the differences in bucking solutions, and estimates of recovery differences using the Best Opening Face (BOF) computer program were determined. A two-inch trim allowance was deemed to be necessary for full length lumber; otherwise the log length was cut back one two-foot interval for BOF runs. Bucking solutions (pencil compared with actual) were deemed to be different if any log length was in a different two-foot length class.

Results and Discussion

The results of the sawmill test are discussed here in terms of recovery effects only. Economic effects will not be determined, or discussed until log hauling effects and costs are identified by FERIC.

Sample Selection

The similarity of the group of logs for each orientation class helps to conclude that the differences in the recovery are, in fact, due to orientation of logs into the mill. Individual loads were combined, objectively, into the two orientation classes, in an attempt to create similar test groups. The designation of orientation class was chosen randomly. Results from BOF runs for pencil bucking solutions, which were decided as though logs were bucked butt-first, showed identical theoretical recoveries of 276 fbm/m^3 (Table 2).

Actual Versus Pencil Bucking Solutions

Best Opening Face computer lumber recovery simulation did not show any recovery difference between pencil and actual bucked log lengths for butt-first feeding (Table 3). There was also no difference in recovery for the pencil bucking solutions between the two orientation classes. There was a 1.4 percent drop in recovery for actual top-first bucking solutions compared with the pencil solutions for the same logs (272 fbm/m^3 versus 276 fbm/m^3).

Eighty percent of the butts ahead stems were bucked into one or more short logs. Of these, only 65 percent were bucked to the same solution as was determined during pencil bucking. Twenty-one percent of the altered solutions affected second and third log lengths only, while 55 percent of the altered solutions changed all short log lengths. For tops ahead bucking, 81 percent of the stems were bucked, of

Table 2

Bucking Solution Results

Orientation	Load	Stems	Single Logs	Logs Bucked	Pencil versus Actual	
					Same	Altered
Butts Ahead	1	78	12	66	34	32
	5	76	12	64	34	30
	7	94	20	74	60	14
	9	104	27	77	56	21
		352	71	281	184	97
Tops Ahead	2	81	15	66	36	30
	4	93	14	79	44	35
	6	94	15	79	50	29
	10	76	20	56	42	14
		344	64	280	172	108

Table 3

Recovery Results
Best Opening Face Computer Analysis
(fbm/m^3)

Orientation	Load	Pencil Bucking	Actual Bucking
Butts Ahead	1	279	279
	5	272	273
	7	277	277
	9	275	274
		276	276
Tops Ahead	2	281	276
	4	274	271
	6	274	269
	10	276	271
		276	272

which 61 percent were unaltered from the pencil solution. Of the stems with altered solution, 70 percent had changes in all log segments, while 9 percent of the changes affected the second and third log lengths only. This is summarized below:

Short Logs Affected (%)
Pencil Versus Actual Bucking Solutions (%)

	Logs Bucked	Different Solutions	Short Logs Affected			
			All	1st & 2nd	1st & 3rd	2nd & 3rd
Butts Ahead	80	35	55	6	18	21
Tops Ahead	81	39	70	8	13	9

The fact that the bucking operator bucked the stem to the same solution as the pencil bucking decision in only 65 percent of the cases, for butt-first feeding, compared with 61 percent for top-first feeding, is surprising. Further analysis of the data does show more of a difference in the two orientation classes, however, which helps to explain the 1.4 percent difference indicated in recovery results ahead of the trimmer (Table 3). This difference is more noticeable if the location of the bucking difference is noted, considering that a difference at the small end of the stem may have less impact on total recovery than a different solution at the large end.

This shows that the difference between pencil and actual bucking solutions affected a higher proportion of larger diameter wood in the tops-first orientation class, than in the butt-first class. Changing the bucking solution by two feet for the 2nd and 3rd logs in a stem should not be as critical to recovery as making a change at the large end of the log.

Sawmill Recovery

Lumber pencil tally, completed ahead of the trimmer, indicated a 1 percent loss in recovery for top first feeding (245 versus 247 fbm/m^3, Table 4). This recovery loss may be attributed to a difference in available log volume and some differences due to diameter loss (and therefore set differences) when the logs are bucked from the top end of the long stem.

The trimmer report for lumber recovery after the two-saw trimmer indicated a 3 percent total loss due to log orientation, and a 2 percent loss due solely to trimmer error, when the wane (top end) of the lumber was trimmed first. Trimmer report and pencil tallies were both after planing estimates.

Table 4

Recovery Results
Sawmill Tally
(fbm/m^3)

Orientation	Load	Pencil Tally	Trimmer Report	Trimming Error (%)
Butts Ahead	1	251	241	
	5	253	235	
	7	248	231	
	9	239	229	
		247	234	5.3
Tops Ahead	2	246	232	
	4	241	224	
	6	244	225	
	10	252	232	
		245	227	7.3

Byproduct Production and Wastage

Chip production from the sawmill test was estimated for each orientation class. Total production from all logs was 36.7 bone dry units (BDU). The estimated split was 17.8 BDUs from the butts forward class, and 18.9 BDUs from the tops first class. Waste production, which included chunks from the bucking and debarking operations were insignificant at 0.3 and 0.1 m^3 for butts forward and tops forward classes, respectively.

Excess log trim, over a five-inch trim allowance, was calculated and classified as avoidable if the short log small-end diameter was greater than five inches. Results are shown below:

Log Trim Volume (m^3)

	Butts Forward Pencil Bucking	Tops Forward Pencil Bucking	Actual Bucking
Total	1.4	1.4	2.8
Avoidable	1.0	0.9	1.7

The additional volume of log trim, 1.4 m^3, from the actual bucking solutions for top-first feeding equates to approximately 0.5 BDUs of chips*. This volume accounts for almost half of the difference in estimated chip production between the two orientation classes.

$$BDU = 1.4\ m^3 \times 35.3147\ ft^3/lb \times 25.52\ lb/ft^3 / 2400$$

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* (Nielson, R.W., D. Wright and J. Dobie. 1985. Conversion Factors for the Forest Products Industry in Western Canada. Special Publication No.SP-24R, Forintek Canada Corp., Vancouver, B.C.

Conclusions

This mill study helps to answer the question of compatibility of mixed log orientation and optimized log bucking. The lost opportunities and profit in the mill can be overcome at a cost, and by combining these costs with the savings in wood delivery costs an optimum operating strategy can be developed.

Conclusions from this study are:

1) Lumber recovery obtained from manual bucking decisions are reduced with top-end feeding. Reduction in recovery with top-end feeding could be as high as 4 percent, or more if logs contain substantial sweep and crook.

2) Computerized bucking solutions should not differ with log orientation, but manual solutions may be highly variable. The ability to shift the stem or saws to allocate any excess trim to the small end of the stem should be incorporated into the mechanical operation of any computerized bucking system.

3) The biggest effect on mill performance associated with stem orientation appears to be at the trimmer, for two-saw trimmers. For mills with non-optimized multi-saw trimmers, trimming error due to mixed stem orientation would probably exceed those suggested for a two-saw trimmer. Optimized bucking systems will not eliminate this loss due to lumber orientation at the trimmer.

4) At today's lumber prices, a 1 percent difference in recovery for a mill producing 100 MMfbm per annum would equate to $200,000 lost revenue each year.

Acknowledgements

The staff and employees at Crestbrook Forest Industries Ltd., who took an interest in this study, especially A. Yonkman, S. Ostlund and C. Lodge, are thanked for their efforts and cooperation in making this project a success. The help of M. Clark and E. Phillips of FERIC in collecting and computerizing the field data is also greatly appreciated. Assistance from B.D. Munro of Forintek, for computer simulation, is acknowledged.

Application of "Snapshot" Scanning and Optimization to Log Bucking

Leon H. Chasson, Applied Scanning Technology, Mountain View, CA

Introduction

About ninety days ago AST completed the installation and evaluation of a bucking system at Weyerhaeuser, Merritt, B.C. The scanning equipment utilized our "snapshot" camera image processing approach to provide the basic stem shape data and value based bucking decision.

Although we now have seven VED "snapshot" systems in operation, this first application to bucking involved an extensive amount of development to produce the results achieved.

Our discussion today will be based on what we earned over the ten month period leading to the successful completion of this project. These results are in no small way due to the support provided by the people at Merritt, principally Lou Brulotte and Henry Christianson, the branch manager. Lou is here today to answer questions and comment on various aspects of this program.

We want to use our experiences at Merritt to help provide you with a more knowledgeable basis for evaluation of bucking in your particular situation. We hope that the extensive learning period of the last year in a real mill situation will perform that function.

Obviously, we would like to infer that our approach to scanning and optimization deserves serious consideration for use in a variety of situations requiring either one or two axis scanning. Nevertheless, we feel that much of what we discuss applies in a very general way to understanding bucking optimization.

Therefore, this presentation has been organized into five parts:

- Introduction to Bucking Optimization
- Scanning and Data Considerations
- Experiences at Merritt with Snapshot Scanning
- Results - Measurements
- Application of Results to Other Locations

Bucking Optimization, Considerations

When we began our experiments at Merritt, we had some preconceived notions on how bucking should be performed. When we completed these experiments some of our opinions were confirmed and some were changed significantly.

Some of those judgements might be considered obvious, while others were unexpected. The latter might also contradict opinions expressed by various people in the industry.

At the outset, it is important to identify the principal objectives of optimization. Basically they fall into two overlapping categories:

1. Reduction of Sweep and Crook
2. Creation of segments which produce lumber with maximum value.

It is obvious that curved log segments produce less lumber than straight ones of the same diameter. Optimization to be effective must provide solutions which minimize curvature within the constraints imposed by mill conditions. Reduction of sweep will, of course, produce more valuable lumber because of the increase in recovery to be obtained. Therefore, we have a gain in both volume and value.

Additionally, there is value to be obtained by recognizing that certain dimensions are more valuable than others. Coupled with this is the concept that lumber recovery increases incrementally at certain diameter breakpoints. Accurate prediction of headrig performance by scanning at the bucking station can potentially lead to decisions which increase recovery and value.

There have been some implications that a bucking system would eliminate the possibility of segments less than eight feet. I believe that this condition does not exist to any appreciable extent.

So with these thoughts in mind, I will proceed accordingly. I have divided the factors to be considered in bucking into two categories, primary and secondary.

Primary

1. Segments Allowed - Inventory Constraints
2. Range of Stem Length
3. Reliable Stem Shape Measurements/Sweep Optimization
4. Value Inputs to Optimization Length

Secondary

5. Value Inputs to Optimization - Diameter Breakpoints/Log Model
6. Bark Effects
7. Primary Breakdown Characteristics
8. Secondary Breakdown Characteristics

In the primary category, the first two items are fairly obvious, but must be given heavy consideration in estimating ROI of a bucking system.

The ability to accomplish these two objectives is limited by the number of ways a stem can be segmented. The ultimate case of no return would be the requirement that 80-90 percent of the segments be of sixteen foot length.

Mill characteristics and market requirements will determine whether the full range of lengths from eight to twenty feet can be cut, and what their percentage distribution must be.

Constraints on the number of shorter pieces, particularly eight and ten foot segments, will greatly reduce the bucking possibilities. Similarly, as the stem lengths decrease below fifty feet, the number of possibilities will also be reduced dramatically. In our discussion of results at Merritt, we will estimate the significance of these constraints in your planning.

Everyone is aware of sweep and crook as being significant factors in optimization. Our experiences have certainly confirmed this fact. Indeed, we believe this factor is really the only significant contributor to volume recovery. Sweep reduction will obviously increase the value of the product as well.

A value optimized system such as the one used at Merritt will also consider the value of each lumber dimension. Within the limitation of segment length distribution, the bucking system will force decisions for the premium lengths. This indeed will increase product value. The next item of importance relates to minimization of sweep and crook. The questions involved here are consideration of optimization technique, scanning concept, and whether scanning on more than one axis is required.

Specialists in simulation and modelling can certainly analyze your situation to determine what is needed in this area; however, simple observation can certainly give you a good idea of what to expect. Our observations and results at Merritt lead us to believe this requirement is highly dependent on the raw material characteristics.

If the sweep is primarily in one plane, then what I call the "banana effect" controls the situation and gravity will tend to place the sweep in a horizontal plane. Our experience with Interior White Spruce clearly indicates that this species requires only single axis scanning. Interior Fir and Pine are another matter altogether. Interior Fir certainly requires two axis scanning if it makes up more than 20 percent of the raw material.

Since sweep and/or crook is such a significant factor in increasing product value, it is important to consider the differences between light curtain scanning and snapshot scanning.

Even a few tenths of inches of sweep can make a significant difference in recovery. Therefore, the stability of the stem during the measurement period is critical. Unfortunately, as sweep increases, the stability of the stem decreases. Therefore, the most critical value measurements occur with the least stable material. This can have a significant impact on either transverse or longitudinal light curtain scanners, due to the motion of the stem during the scan period, which may take several seconds. With a snapshot system, the whole stem is scanned in a fraction (.100-.200) of a second, thereby eliminating the situation which may occur with light curtains. The next issue, of course, relates to the decision process segmenting a stem with sweep/crook.

Based upon experience at Merritt and recent discussions with others working on similar problems, it appears that we have all come to the same conclusion as to what should be done in this area.

Before proceeding, I should indicate in general how our value optimization works. In about .2 seconds, the stem is scanned and its shape in one or two axes determined. The processor then examines every possible combination of segments. The value of each segment is based upon its length, diameter and sweep. The solution with highest value is selected. The total processing time is about .500-.800 seconds.

If the segment is curved, its value is reduced to that of the "equivalent straight log". The actual processing technique is, of course, proprietary to each supplier. Our approach was empirical. We had the opportunity last summer and fall to conduct extensive tests with our system at Merritt to evaluate several algorithms. We have found the final result to be a very effective one for this application.

The next consideration is that of length. This is relatively straightforward, since current prices are used for the segment evaluation.

The next items are believed to be of secondary importance in the decision process. I am sure there will be some questions on your part in this area. I will, however, present our thoughts for your consideration.

In looking at each segment, the processor estimates its value as green lumber. A prinicpal factor here is what the primary breakdown operation will do to it.

Since we know the exact shape of each segment (ignoring bark for the moment), it might be possible to predict what kind of lumber would come out at the sorter. We certainly do this in our optimization; however, we believe that it is not possible to accurately predict what a Chip-N-Saw, quad, etc. will do to a particular segment. We cannot predict log orientation from data at the bucking system. Even with scanning at the headrig, the lack of orientation minimizes our ability to select segments based upon "critical" diameter breakpoints.

This is very much the case with a Chip-N-Saw and less so with a sharp chain, twin/quad, where we might assume that the log would be oriented "horns down". The impact of bark on optimization again relates to the ability to select diameter breakpoints which increase recovery.

If, as we observed, sweep, crook and length optimization play the principal role, then bark should not be a major factor in recovery optimization. A bark factor for reduction in diameter should be sufficient. In those cases where it is believed that primary breakdown results can be more accurately predicted, the stems must have their bark removed prior to scanning.

Again, looking at primary and secondary breakdown equipment, we are faced with the problem of predicting what they will do, even given perfect knowlege of the stem shape. Before our mill experiments at Merritt were conducted, I believed that something could be done in this area. Now, I am quite doubtful. I would certainly be interested in comments from the audience and participants on this subject.

AST Snapshot System

At this point I would like to briefly describe how our snapshot scanning systems operate. In particular, I would like to emphasize their potential in bucking situations.

The VED (Video-Edge-Detection) "snapshot" system was developed in 1981, for MacMillan Bloedel Research. This original scanning package was placed in operation on a carriage at Port Alberni.

Since mid 1984, six additional systems have been placed in operation, with three more scheduled for completion this summer.

The basic concept involves the use of television cameras as sensors. By appropriate use of optics and lighting, log edges are illuminated in a manner to provide good contrast. A linear array of cameras is placed directly overhead to observe the log or stem in the horizontal plane. (In a two axis system, there would be two arrays separated by about ninety degrees.)

Analog video data is obtained from each camera in 1/60 second. Therefore, even with serial processing, data is available in .100-.200 milliseconds.

The principal problem is, of course, to digitize and recognize the edge data in real time. This permits the whole system to operate in a "snapshot" mode.

In order to accomplish this complex operation, it was necessary to develop an extremely high speed preprocessor and couple its output to one or more microcomputers.

Over a period of time the optimization process became more complex and several upgrades in microcomputer hardware have been made. Additionally, the recent availability of solid state rather than vidicon cameras has made it possible to simplify installation and improve reliability and accuracy.

From the standpoint of bucking, it was believed that the VED snapshot concept offered the potential of achieving real gains in a number of existing or upgraded mill configurations.

The reasons obviously relate to the ability to generate real log shape data in 100-200 milliseconds, and complete the optimization process in an additional 300-500 milliseconds. Another factor is of course data frequency. Diameter and shape data is provided every 2 to 4 inches along the stem. This is important when considering some of the more refined aspects of sweep and crook optimization.

This snapshot approach can be applied to one or more axes; however, it is obviously easier to retrofit a single axis system. Therefore, the requirement for the second axis should be clearly established.

Merritt Installation

Now I would like to describe our experiences at Merritt with our first bucking application. Again, I want to express our appreciation for the support provided by the people at Merritt. Lou Brulotte and I spent many hours scanning and rescanning stems with various optimization parameters.

The camera configuration was set up for stems up to sixty feet with eight cameras placed in a line about eighteen feet overhead. The lighting configuration was laid out to match mill constraints, high on the infeed side to clear the deck loading equipment, and lower to match the existing wall structure.

There is a single cut-off saw. After the stem is loaded onto the infeed conveyor, it moves forward about two to three feet before the scan is initiated. In this particular case, the lights are turned on briefly at this time. This saves power and increases lamp lifetime. As the stem passes the saw, the scanning and optimization has been completed, and the recommended segments are presented on the operator's display. The segments are then cut manually. After each cut, the remaining length is also displayed. Both the recommended and actual cuts are tabulated.

A lightweight roof structure has been attached to the existing building. The structure serves the dual purpose of supporting the cameras and lights, and preventing direct sunlight from affecting system operation.

Nevertheless, ambient lighting varies dramatically throughout the day, particularly during the winter months. Considerable design planning and the development of some new data processing techniques were necessary to be able to maintain performance under these conditions. The stem background is a solid conveyor and chain.

Planning and construction of the overhead structures was handled by Lou Brulotte and his associates at Merritt. I think I will defer comments on this part of the installation to Lou.

The processing electronics were placed in the same room with the operator. The terminal, which controls the prices, reports and other parameters, was placed nearby. The operator views the fluorescent display which provides the log length and bucking decisions.

Shortly after the system was placed in operation, a labor dispute prevented further large-scale testing. It was possible, however, to evaluate and fine tune the algorithm, which generates the "equivalent straight log".

Since the optimization occurs in a fraction of a second, it was necessary to develop techniques which handled the gamut of stem shapes in an efficient manner. It was possible to evaluate a number of techniques since we could run the same stem repeatedly through the scan zone.

When the labor dispute was settled last December, we were ready to go.

The next step was the most critical, since it involved development of a reliable technique for measuring the uplift in product value.

Results

As usual, the problem of reliably measuring recovery and value uplift was quite formidable. As in many situations, the mill had both a small and large log input and one sorter tally. Therefore, it was not possible to run continuous large scale tests without disrupting normal mill operations.

Fortunately, Lou had been running weekly twenty-five log performance tests on the Chip-N-Saw over a period of time. Although these tests were in small samples, there was no question about input scale and recovery information.

With a large number of small-scale tests, which are well documented, it is possible to sort out the effect of other variables on recovery. In fact, this approach to performance testing may well be more effective than large-scale tests.

In the large-scale tests, one assumes that enough material has been processed to average most mill variables. With multiple small-scale tests, a number of very informative analyses can be performed. The first is a measure of the variability of recovery on a week to week basis. This should first be done in the manual mode, without scanning. The variability of recovery immediately provides some indication of the validity of a comparative test in the scanning mode. This variability is typically expressed as the standard deviation from the average or mean recovery obtained on a group of tests. If the standard deviation is small compared with recovery gain to be expected, then all is well. A few tests can be performed in the scanning mode, and the results viewed with some degree of confidence. If, however, you are expecting three percent improvement in recovery with a standard deviation of three to six percent of the mean, then it is necessary to eliminate the effect of mill variables.

Under these conditions more analysis is required. This effort, however, has an additional payoff in that one can use this work to identify other factors which affect mill recovery. Our experiences at Merritt are probably typical of what may be observed in other situations. In reviewing many Chip-N-Saw tests, it was found that recovery varied about three to four percent. The principal factor was log diameter. This, of course, was to be expected, since much theoretical and experimental data has indicated that this was the case. Another factor was species or the condition of the raw material. By just considering tests with fresh white spruce and categorizing the logs by "set" diameter, it was possible to reduce this variability to less than 1.5 percent. Since we were dealing with small logs, individual data was grouped into three diameter categories, 5-6 in., 6-7 in., and 7-8 in.. These categories represented about ninety percent of the material processed on these tests.

The total number of tests evaluated to date, with and without bucking decisions, is about twenty or a sample of 500 accurately scaled logs.

On a value basis, the weighted average uplift in recovery was approximately three percent. Since this is a value optimized system, the real gain to be considered is in $/cubic foot rather than board feet/cubic foot. Calculations of value uplift are more tedious since each board produced must be converted to a dollar value before summation. This whole exercise reduces to relative simplicity if the mill had one input. The tally printouts at the sorter could, of course, be easily converted to dollar values.

The calculations performed to date are very encouraging. Six tests totalling about 300 logs were used in this process. Three tests were run before optimization and three afterward. The average increase in value was 6.7 percent. The most encouraging thing about each group of three tests was that the deviation was about one percent between tests. This certainly helped in establishing confidence in the 6.7 percent result.

Application of Experiences at Merritt to Other Locations

It should be clear at this point that we have developed some degree of familiarity with the problems and considerations associated with installation and effective operation of bucking systems.

Based upon this experience, there are several important items we should be reviewing to determine if bucking optimization would be profitable in a particular mill situation.

What I mean by optimization is complete stem shape measurement coupled with a decision algorithm appropriate to achieving maximum value uplift. It is possible in some situations, that a much simpler configuration would be appropriate; for example, a mill which processes large straight stems where the range of bucking decision is limited to say 16-20 feet. Another situation might be where the raw material lengths are primarily in the 30-45 foot range. In these situations a relatively simple length measurement operation may be quite adequate.

The first considerations relate to the mill operation, primary and secondary breakdown systems, production levels, and the nature of the raw material.

If an analysis of the basic considerations proves to be encouraging, we would then look at the problems associated with installation. In some cases a retrofit might be accomplished with little mechanical work, thereby substantially reducing the total package cost. In other situations, modernization of the infeed to improve stem processing efficiency might be necessary to make the overall task worthwhile. For example, a mill with two bucking stations might be converted to one processing center with multiple cut-off saws.

In order to provide some perspective of what might be accomplished in a particular installation, I have prepared a slide which illustrates the expected gains which could be achieved as a function of the more critical parameters. In this slide we have considered effects of stem length, curvature, and segments permitted.

As you can see, our only measured data points represent the results at Merritt. The other points are extrapolations based on some simulation work performed over the last twenty-four months. Obviously, we would like to convert some of these "possible" numbers to real data. We are looking forward to doing just that, later this year.

Actual and Expected Value Uplift for Small Log Bucking System

Typical Stem Length	20-45 feet		45-70 feet	
Segments Allowed	8-20 ft.	12-20 ft.	8-20 ft.	12-20 ft.
Category A	5%	3%	9%	6.7%
Category B	6%	5%	11%	8%

Raw material categories

A - Moderate sweep (mainly one plane)

B - Significant sweep (e.g., interior fir)

Experience in Implementing Computer Optimized Bucking

Lou Brulotte, Weyerhaeuser Canada, Ltd., Merritt, B.C.

When I started for Weyerhaeuser six years ago, the Area Manager, Henry Christianson, wanted some kind of assistance for the cut-off saw operator. With the operator seated across from the log stops, it is very difficult for him to see the end of the log. We started off by marking the conveyor, but this was very crude and the marks did not last. We then went to a closed circuit, television system, using a camera directly above the conveyor. Using a wide angle lens and a 19-inch monitor we were able to see only 20 feet of the conveyor. This still was not adequate.

Two years ago Henry and I attended, in Vancouver, a Forintek seminar on log scanning. After hearing Leon's presentation on the VED system, I immediately thought of the bucking application. After having a lengthy talk with Leon, we both agreed to pursue it further. Leon made a visit to our mill in Merritt and became quite excited at the challenge. This started the ball rolling.

With the help of log scalers and Quality Control, we began measuring length and diameter of stems in the yard. We followed these stems through the C.O.S., recording operator decisions on the bucking. We also recorded diameters and sets at the CNS. Using this information, preliminary comparison showed a 7 to 12 percent increase in recovery.

Installation of the equipment went fairly smoothly. A roof was constructed over the log deck to keep the direct sunshine off the conveyor. Catwalks were installed at the center and outside edges parallel to the conveyor. Eight cameras were installed 18 feet directly over the conveyor, with each camera covering an 84- to 90-inch field of view. Two banks of 60 lights were installed on each side, at 45 degree angles, 18 feet above the conveyor. The catwalk allowed us to install the cameras and lights while the mill was operating. There was only one modification to the conveyor. A hole was cut so that photocells could be mounted. Total installation took two weeks to complete. Applied Scanning personnel then arrived to calibrate and perform a system checkout.

Maintenance of the system the past six months has been confined to replacing four lamps and one low voltage transformer which were damaged by a log. The greatest amount of time was spent in tuning the system. Tuning factors include maximum taper allowed per cut, allowable sweep and crook. The price table is used to control the inventory and distribution of lengths.

Mill benefits include straighter logs and consistent bucking from shift to shift and day to day. The easiest way to measure the benefits is by recovery. Since we installed the CNS, I have been doing recovery checks every two weeks. This is measuring diameter and length of the logs just before the CNS and pencil trimming the lumber at the outfeed. Using these numbers, this gave us a good baseline to work from. Since the log scanner was installed, the CNS recovery tests have increased by 3 percent with the biggest increase being in the 6 to 7 inch range.

Stem Optimizing: A Critical Link in Sawmill Production Control

Gianni Scaramella, Mel Cruickshank Equipment Ltd., Toronto, Ont.

Introduction

What is meant by Sawmill Production Control?

Control means manufacturing the right logs at the right time. It means sustaining the highest profit for the sawmill and, above all, being in control of the sawmill production process. Lumber companies must be able to respond to market opportunities and shifts in raw material supply. What does this mean? In practice, it means obtaining the right logs from the stem supply entering the sawmill. Real estate salesmen say Location, location, location. We say THE RIGHT LOGS, THE RIGHT LOGS, THE RIGHT LOGS. For any given population of raw material, end markets, and sawmill equipment, there is an optimum population of logs that should be cut from those stems. These logs will maximize revenue, and hence sawmill profit. If you make a mistake on the merchandising deck, you can never regain the loss.

This paper will first introduce the players supplying the various components, and follow with a description of the production optimizing system itself.

The production optimizing system has three sub-components:

- the production scheduling system.
- the stem optimizing, or log manufacturing system.
- the scanners.

These products are designed to work together and provide an integrated, synergistic system, but they also work with other systems. You could purchase any of these three components separately and integrate them with other manufacturers' units.

Two Canadian installations will be starting up in late 1989 with our equipment. European installations, on the other hand, number well over 50 optimizers and 150 scanners.

The Players

MCE

Mel Cruickshank Equipment, or MCE, are specialists in obtaining advanced European technology, particularly in the sawmill industry. MCE has been in business for the last 35 years selling products that range from conveyor belting to chippers to entire sawmill lines.

MCE is the exclusive Canadian distributor for KEBA, AIT, and LINCK. MCE not only supplies equipment, but also ensures that the appropriate level of service and spares is available. For example, they have arranged to have KEBA products serviced through a Vancouver-based electronics firm, Elmec Engineering. Elmec's technician has spent several months in Austria being trained by KEBA.

KEBA

KEBA was started in 1969, and until May was known as Elecktronikbau. Since 1969 it has grown into a company employing over 160 people and selling its products all over the world.

KEBA has focussed on three major markets: sawmills, banks, and industrial automation. The two non-sawmilling groups supply products ranging from components of automatic teller machines to ignition systems for moto-cross bicycles.

In Canada, KEBA has supplied the stem optimizing scanners and software as well as the total process control for the two new LINCK sawmills. In Europe, KEBA has an installed base of over 50 stem optimizers and over 140 scanners.

AIT

AIT is another Austrian company and specializes in micro-processor based information products. They supply the Production Control Optimizer, which optimizes cutting patterns given constraints in log supply. MCE is in the process of bringing AIT software technology to Canada.

Production Optimizing System

There are three components to the Production Optimizing System, or Log Generator, as it is also called. These are the Production Scheduling System, the Stem Optimizer, and the Scanners.

One basic principle of these components is to put the processing intelligence where it is needed. The Production Optimizing System has up to four microprocessors, depending on the number of modules and the system configuration.

The scanner has its own 8-bit chip that controls sequencing of the infra-red light beams, calculates the real log shape and monitors the scanner components for faults.

The stem optimizer will use either one or two microprocessors, depending on the model of optimizer.

Interopt 1000, the crook and sweep optimizer, has two models that depend, in turn, on the stem throughput. For throughput of up to 4 stems per minute an HP 1000 is used. For throughput between 4 to 10 stems per minute, the Interopt 1000 uses an HP 9000 processor with RISC architecture.

Interopt 88, the model without crook and sweep, has an Intel 8088 chip that controls the Stem Optimizing system, looks after interrupts and other housekeeping functions. A 32-bit Motorola chip then does the real-time Stem Optimizing.

The production scheduler will run on any 32-bit microprocessor whose operating system has a Fortran 77 compiler. This is an offline process and is our management information system.

The first component of the Production Optimizing System is the Production Scheduling System, or PSS.

The PSS is designed to be both a management information tool, and an operations production control tool. It is best to visualize the production scheduling system as the management control tool that drives the stem merchandiser. The PSS forces the production staff to forecast stem supplies, and combine this information with exact sales data. As historic data is built up on stems coming out of a specific logging camp, or supplier, the forecasts become more accurate.

The PSS has two components: a Production Optimizer and a Production Scheduler. The Production Scheduler is designed (primarily) for sawmills that have log sorting. Log sorting allows a sawmill to produce batches of lumber to specific orders. The function of the Production Scheduler is to schedule the actual production to minimize work stoppage and to tell the board sorters what material is coming and to which customer the materials belongs. Log sorting is not common in B.C., so I will not expand on this point.

The Production Optimizer, on the other hand, can be used by any sawmill. It incorporates both a linear program and a dynamic cutting pattern optimizer. These programs interact dynamically to calculate the most profitable way to break down logs, given constraints on the log supply, the market demand for lumber, and the existing sawmill equipment.

The dynamic cutting pattern optimizer is the first component. A brief discussion of its output will highlight some fundamental facts of log merchandising.

Figure 1 contains an example of typical output from this module. The figure shows maximum revenue per cubic metre for a range of log diameters and lengths, using real data provided by a B.C. operator. The figure shows:

- Importance of top end diameter especially to small logs and the resolution of scanning required.

As you can see, the revenue can show very large savings for smaller diameters. In addition, a difference of 10 m-m can mean $20 per cubic metre in revenue.

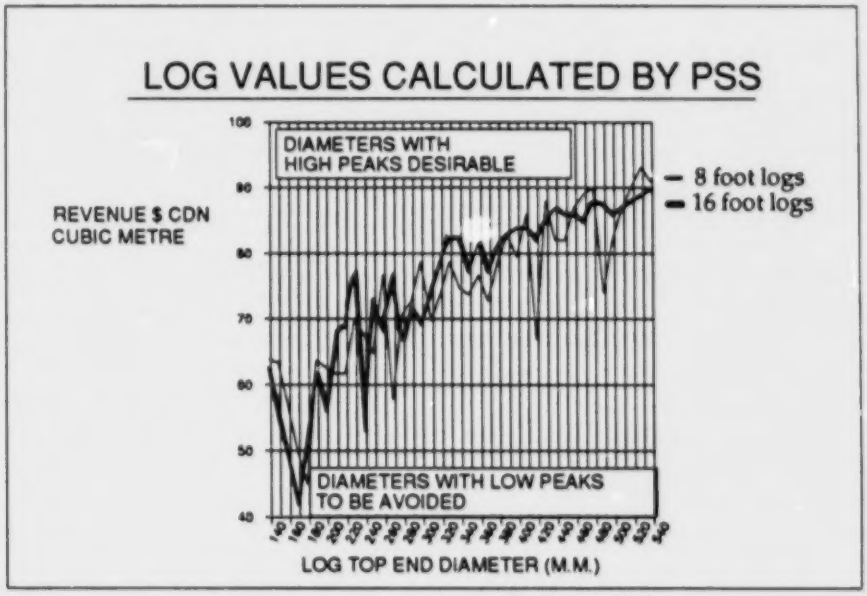

LOG VALUES CALCULATED BY PSS
DIAMETERS WITH HIGH PEAKS DESIRABLE
DIAMETERS WITH LOW PEAKS TO BE AVOIDED
REVENUE $ CDN CUBIC METRE
8 foot logs
16 foot logs
LOG TOP END DIAMETER (M.M.)

FIGURE 1

Where the Production Optimizer really begins to shine is that it combines the cutting pattern optimizer with a linear program. This linear program maximizes a profit function that defines profit as:

lumber (quantity x price) - log costs + byproduct revenue - overproduction costs.

It assumes that, for the short term, all variable costs are fixed. This function is maximized subject to the constraints of:

- available log supply
- desired product mix and breakdown equipment in the sawmill.

See Figure 2 to see how the cutting pattern program and linear program interact. A reduced linear program is run first. This program uses cutting patterns calculated by the dynamic cutting pattern optimizer. The output of the linear program is then returned to the cutting pattern optimizer. The new cutting patterns are added to the linear program. This rapidly forces the linear program to converge on the optimum solution. The optimum solution is a specific set of cutting patterns for a specific number of logs.

To summarize, the cutting pattern optimizer assumes that log supplies are infinite, and that the quantity of lumber produced for each dimension desired is infinite. Useful information, but not a revolutionary step. The key lies in combining this information with a linear program.

The linear program forces the operator to define the log population exactly. If logs are sorted, the operator can use real log inventory data. If there is no log sorting, the operator will have to forecast log production from the bucking saw. In addition, one knows exactly the dimensions and volumes of lumber that one wants to produce. Combining the two modules makes it possible to define the optimum cutting patterns, for a given log population.

This allows the optimizing of the production process, and brings the scheduling of a sawmill further into the realms of the factory of the future.

Sawmill management can use the Production Optimizer to calculate the effects of:

- Delivery costs - the cost of increased or decreased time horizons.
- Effects of introducing new product-incremental revenue.
- Effects of changing raw material supply-incremental revenue.
- Effects of introducing new machinery-incremental revenue.

Stem Optimizer: The Interopt Family

The second component of the Production Optimizing System is the Interopt family of stem optimizers. Two members of this family are suitable for the North American market:

- 1- Interopt 1000: the full crook and sweep optimizer
- 2- Interopt 88: the original version that does not have crook and sweep capabilities, but can accept input from double axis scanners.

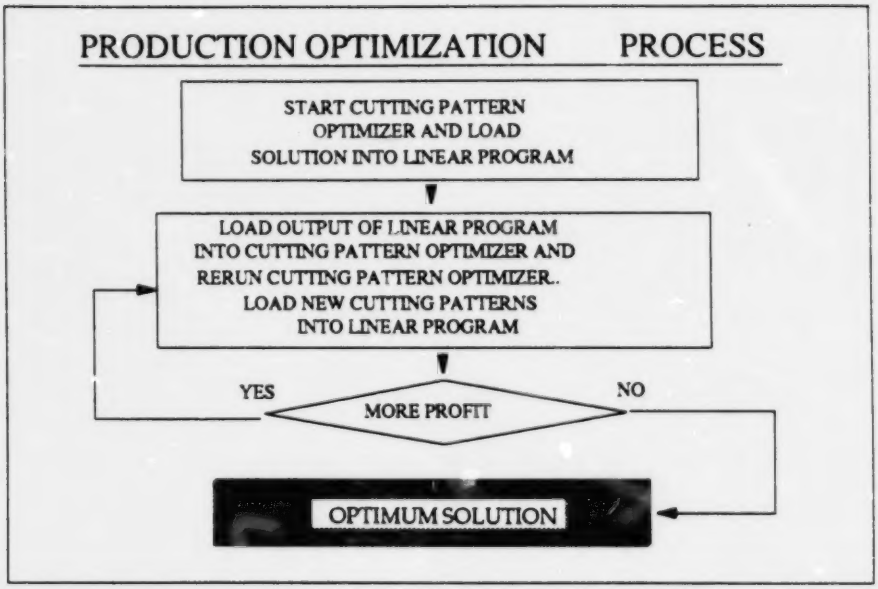

PRODUCTION OPTIMIZATION PROCESS
START CUTTING PATTERN OPTIMIZER AND LOAD SOLUTION INTO LINEAR PROGRAM
LOAD OUTPUT OF LINEAR PROGRAM INTO CUTTING PATTERN OPTIMIZER AND RERUN CUTTING PATTERN OPTIMIZER.. LOAD NEW CUTTING PATTERNS INTO LINEAR PROGRAM
YES
MORE PROFIT
NO
OPTIMUM SOLUTION

FIGURE 2

Where the Production Optimizer really begins to shine is that it combines the cutting pattern optimizer with a linear program. This linear program maximizes a profit function that defines profit as:

lumber (quantity x price) - log costs + byproduct revenue - overproduction costs.

It assumes that, for the short term, all variable costs are fixed. This function is maximized subject to the constraints of:

- available log supply
- desired product mix and breakdown equipment in the sawmill.

See Figure 2 to see how the cutting pattern program and linear program interact. A reduced linear program is run first. This program uses cutting patterns calculated by the dynamic cutting pattern optimizer. The output of the linear program is then returned to the cutting pattern optimizer. The new cutting patterns are added to the linear program. This rapidly forces the linear program to converge on the optimum solution. The optimum solution is a specific set of cutting patterns for a specific number of logs.

To summarize, the cutting pattern optimizer assumes that log supplies are infinite, and that the quantity of lumber produced for each dimension desired is infinite. Useful information, but not a revolutionary step. The key lies in combining this information with a linear program.

The linear program forces the operator to define the log population exactly. If logs are sorted, the operator can use real log inventory data. If there is no log sorting, the operator will have to forecast log production from the bucking saw. In addition, one knows exactly the dimensions and volumes of lumber that one wants to produce. Combining the two modules makes it possible to define the optimum cutting patterns, for a given log population.

This allows the optimizing of the production process, and brings the scheduling of a sawmill further into the realms of the factory of the future.

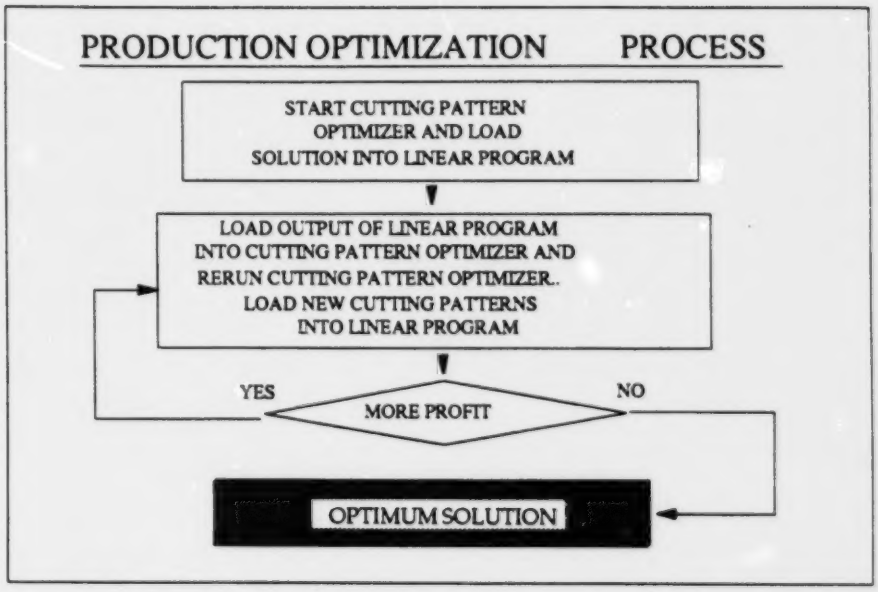
Sawmill management can use the Production Optimizer to calculate the effects of:

- Delivery costs - the cost of increased or decreased time horizons.
- Effects of introducing new product-incremental revenue.
- Effects of changing raw material supply-incremental revenue.
- Effects of introducing new machinery-incremental revenue.

Stem Optimizer: The Interopt Family

The second component of the Production Optimizing System is the Interopt family of stem optimizers. Two members of this family are suitable for the North American market:

- 1- Interopt 1000: the full crook and sweep optimizer
- 2- Interopt 88: the original version that does not have crook and sweep capabilities, but can accept input from double axis scanners.


PRODUCTION OPTIMIZATION PROCESS
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YES
MORE PROFIT
NO
OPTIMUM SOLUTION

FIGURE 2

The Interopt is a log generator and the PSS is a log specifier. It is only logical that the output of the PSS be loaded into Interopt. PSS input is sent to Interopt through a serial connection, enabling Interopt to cut logs based on PSS specifications (see Figure 3).

The complete operation flows as follows:

1. Forecast log production.
2. Analyze these logs and identify the best cutting patterns, and the value of each cutting pattern.
3. Calculate those logs you want to produce. These are specified by top-end diameter, length and quantity. The logs are then loaded into Interopt, and Interopt tries to section just those specified.
4. After a period, see what logs Interopt has found, calculate how successful you have been, and then rerun the PSS.

The Basic System

The basic system is composed of the CPU, a scanner, pulse generator, and the display unit (see Figure 4).

In Europe, about 50 percent of the Interopt 88 installations use the stem optimizer as an advisory system. The stem deck operator manually controls the bucking process but uses the bucking suggestions from the Interopt.

The Complete System

The complete system provides total process control and an interface to the Production Optimizing System (see Figure 5). Orders and dimensions data are combined with input about stems from the scanners and from the stem evaluation process. The system in turn produces log classification suggestions, listings, stem data and statistics (see Figure 6).

There are a number of parameters that can be input to the stem optimizer that will fine tune it to each installation. Parameters like the urgency of orders, urgency of dimensions, and log quality will change the stem sectioning as desired. If the actual taper ratio is larger than estimated, the system will produce (predominantly) shorter logs. Conversely, if the actual taper ratio is smaller, the logs produced will be predominantly longer.

The algorithm for selecting the best log mix uses the actual log values, and calculates all the combinations of possible orders that can be cut from a stem before choosing the combination that provides the highest value from the stem (see Figure 7).

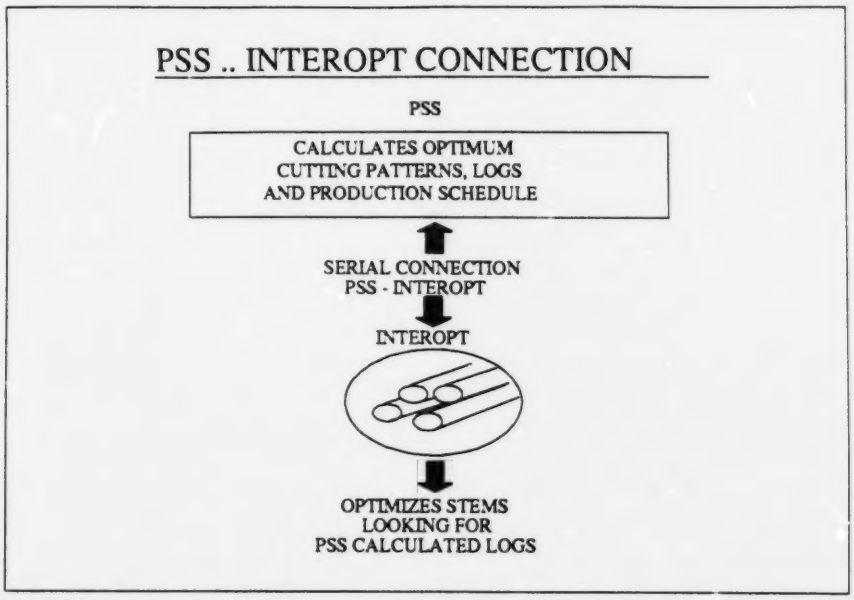
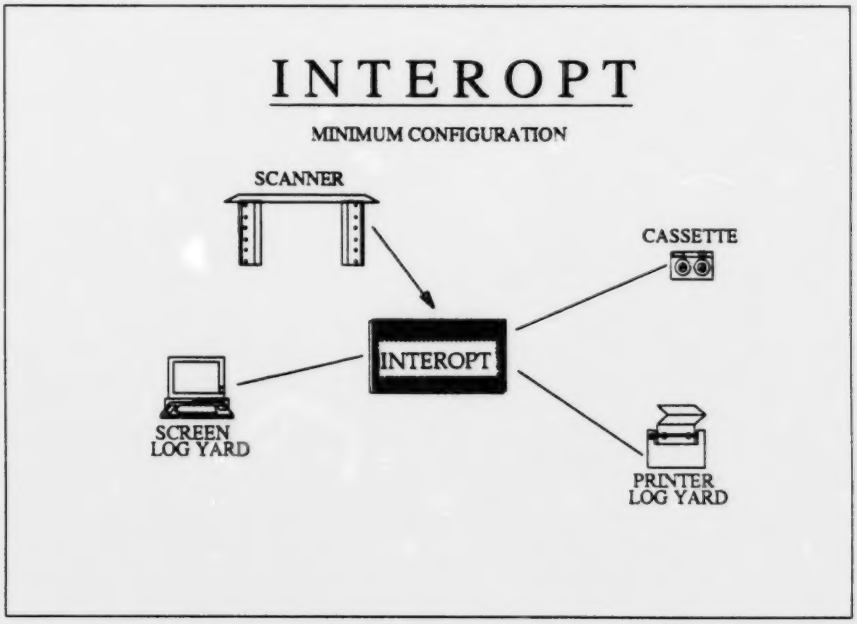


FIGURE 3

FIGURE 4



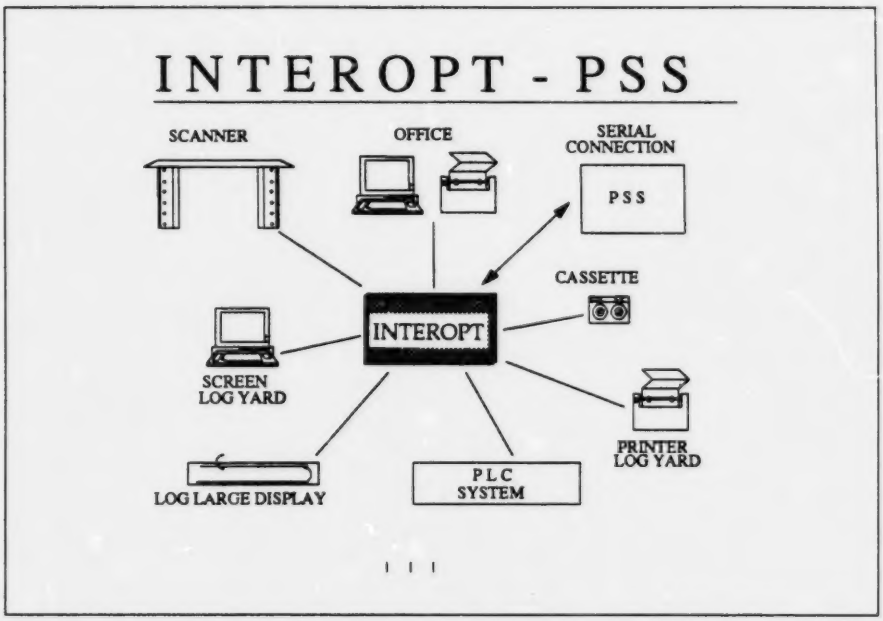

INTEROPT - PSS
SCANNER
OFFICE
SERIAL CONNECTION
PSS
CASSETTE
INTEROPT
SCREEN LOG YARD
PRINTER LOG YARD
LOG LARGE DISPLAY
PLC SYSTEM

FIGURE 5

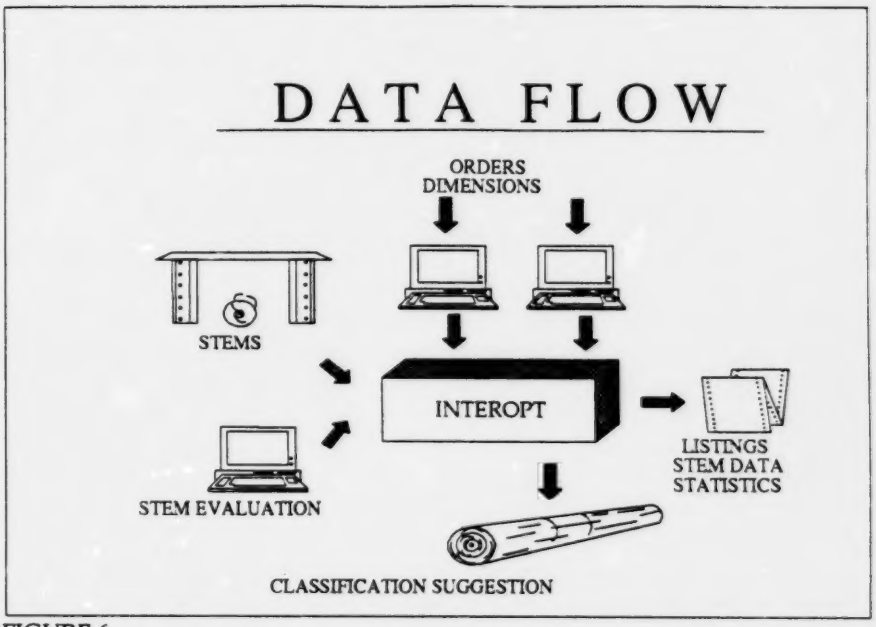
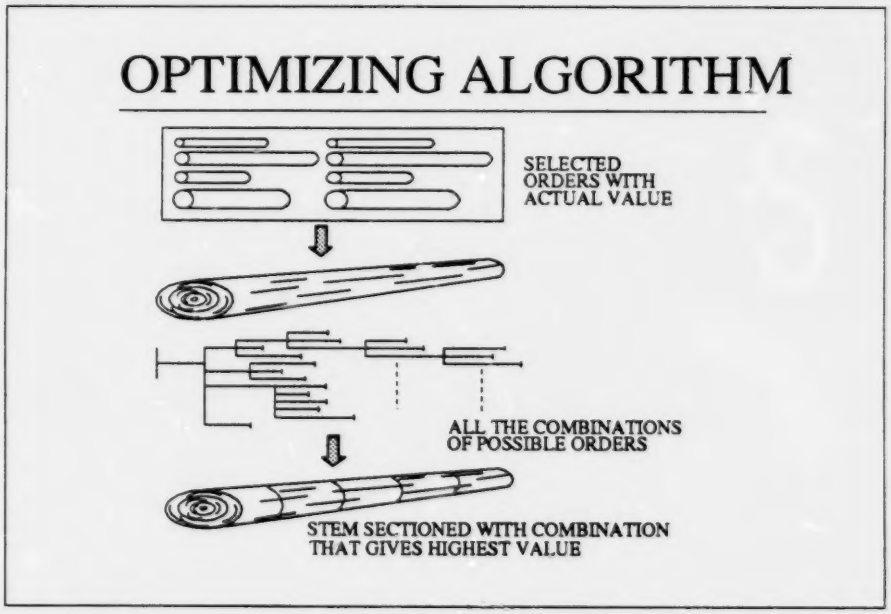


FIGURE 6

FIGURE 7



Crook and Sweep Calculation

The crook and sweep calculator starts at the butt end of the stem and works forward in 10 centimetre increments to the end, calculating the largest diameter cylinders that fit inside the stem for all lengths in the order list. These values are loaded into the Crook and Sweep table. When the log has been scanned, stem values are optimized using the values from the Crook and Sweep table.

Printouts

The system produces four kinds of printout, based on the stages of the process. Stem scanning produces stem data. Sectioning produces individual stem listings with sectioning, and stem lists. The bucking process produces lists of logs generated and forecast lumber volumes. These reports can be customized for each intallation.

The Scanner: The LCS2000 Family

Operating Principles

KEBA has been using scanners in sawmills for the last 15 years and produce their own scanner, the LCS2000 series. These scanners provide the three requirements for any measuring system:

- precise measurement of diameter and sweep.
- precise measurement of length.
- almost 100 percent uptime.

Their scanners all work on the same principle (see Figure 8). Stems are measured by passing them lengthwise through a light curtain. The diameter is measured by monitoring which light beam is being broken.

The length is measured by counting the pulses generated by the movement of the stem conveyor. Although KEBA offers both camera scanners and infra-red scanners, they recommend using the infra-red scanners.

Scanners can be supplied with the following combination of features:

- double axis or single axis measurement
- variety of diameter ranges
- variety of resolutions

THE SCANNER: THE LCS2000 FAMILY

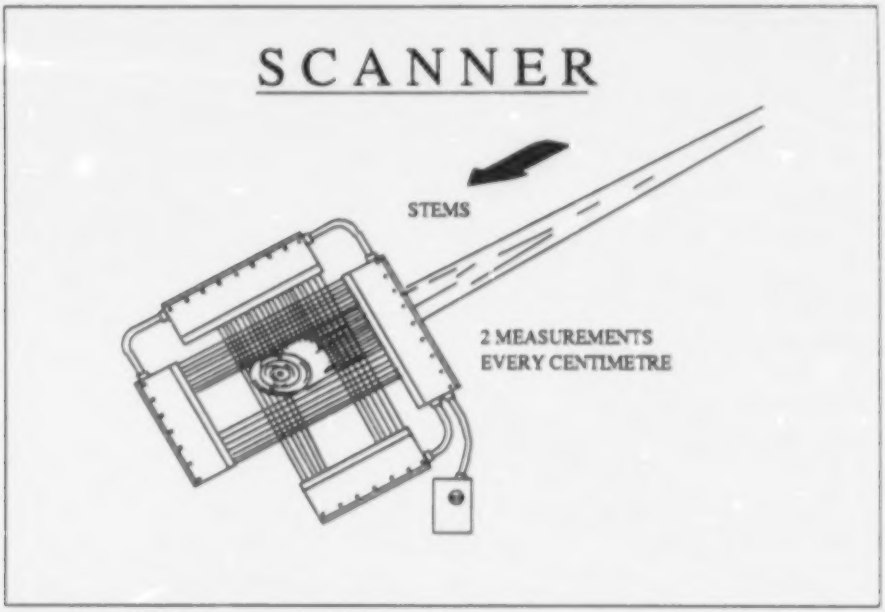


FIGURE 8

The advantages of the infra-red scanners over camera-based scanners are:

- They are not affected by ambient light. The detection principle works on measuring transient pulses. So unless the sun is shining directly on the receivers saturating them, they can measure the presence of the pulse from the transmitter. What this means in practice is that you don't have to build a lightproof cover over the scanner.

- As each scanner is tested in the "atmospheric" chamber prior to shipment, it is guaranteed to function from +50°C to -40°C. The housing is waterproof and dustproof, so it can be left under the elements. However, it is recommended that you put a cover over the scanner so that if it requires servicing, the maintenance staff can be protected from the rain!

- They require minimal maintenance. As there are no moving parts in the scanner, they are virtually maintenance-free. If a component is defective, circuit boards can easily be removed by any mill personnel.

- They are tolerant of misalignment. The pulse of infra-red light will diffract when it leaves the emitter. This diffraction eliminates the need for precise alignment.

The scanner is accurate to within 1 mm on diameter, and to 1 cm on length (assuming no conveyor slippage) (see Figure 9).

When measuring the diameter, interferences on the edge of the wood (branch ends, raggedness, dirt, etc.) have to be interpreted properly. Assuming that the software is sufficiently intelligent in the first place, a large number of measurements have to be taken for these defects to be recognized. KEBA scanners measure the diameter of the stem at least 150 times each second when the pulse encoder is running at the maximum rate of 200 Hz.

In addition to determining the real length of a stem, the scanner has to decide where the stem begins and where it ends when there are:

- angle cuts
- broken ends
- splintered ends

KEBA scanners have all these features. The software has been refined over the 8 years that this scanner has been produced and it can truly be considered an "expert system" for stem detection.

Diagnostics

The built-in diagnostics on the optimizer continuously check for the following:

- dirt contaminating emitters or receivers
- malfunction of an emitter or receiver
- overflow of stem data in memory buffer

If any error condition is detected, the operator is immediately notified.

The Benefits

This system provides substantial benefits when compared with the manual bucking process. As illustrated in Figure 10, the percentage of logs with less than 0.2 inches in top diameter error is substantially higher, and the average error in top diameter (measured in inches) is substantially lower. The shaded area in the graph represents the increased recovery obtained by using a stem optimizer.

KEBA estimates that for a typical B.C. sawmill processing 42-foot stems, the Interopt 1000 will increase recovery by 4 percent, eliminate production stoppages due to misshapen pieces entering the sawmill, and increase value of the lumber mix.

SCANNER SPECS

One axis measurement
with pulse encoder

Twin axis measurement
with pulse encoder

TYPE
Infra-red light beams. Not sensitive to ambient light

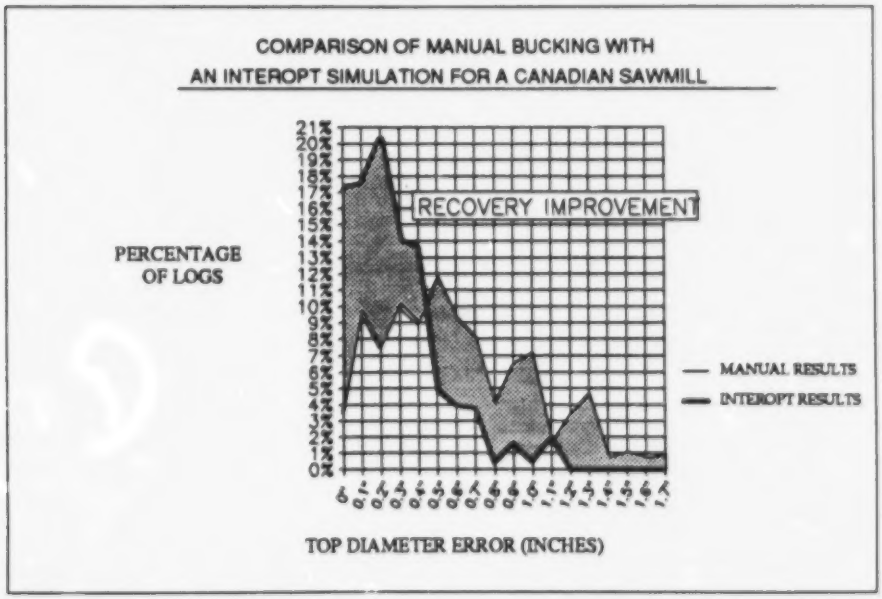
RESOLUTION
Diameter: 1, 2, 4 mm
Length 1 cm. Assumes no slippage on conveyor

MEASURING RANGE
500, 1000, 1500 mm

FEATURES
The scanner posesses its own processor. This chip calculates the stem profile and checks all scanner components. If a component is faulty the operator is notified.

FIGURE 9

FIGURE 10



Bucking Optimization with "Real Shape" Scanning

Paul Sullivan, Applied Theory, Corvallis, Oregon

Good Afternoon, Gentlemen.

In the spirit of this seminar, I have obtained an exhibit (Table 1) outlining Bucking Optimizer results as compiled by one of the larger wood processors.

The figures reflecting "Average Increase" in both volume and dollar value are very close to those presented by Forintek speakers, which they compiled independently at organizations other than the company represented in the ATI document.

Note log five (5), where the operator decision resulted in a volume of 150.7 feet, valued at $30.18 US, whereas the Bucking Optimizer's decision offered 177.4 feet, valued at $35.46 US. This reflects a 17.72 percent increase in volume and a 17.50 percent increase in log volume.

Note further, as you study the results of the 16 logs on this survey, the operator arrived at the proper solution only 6 times out of 16; this is obviously unacceptable.

Each hour, many critical decisions are made at the bucking station. These decisions affect the profitability of your operation at every level, from the headrig to the shipping department. When the decisions are made correctly, flow is enhanced and the mill manufactures the types of product required to meet demand. Problems at the bucking station translate into lost revenue through poor mill flow, remanufacture costs, and a backlog of product that may not be marketable.

The advantage of an optimized bucking line is the smoothness and consistency it affords your day-to-day operation. The Applied Theory Maximizer™goes beyond this. The advantage of the Maximizer lies in the unique way it looks at a stem to collect data, and the types of comparisons it is capable of making based on that data. Because of this ability, we feel the Maximizer is the most powerful bucking system available to the industry today. The Bucking Maximizer is equipped with dual axis scanning, Real Shape Solutions™,and the ability to detect and solve for sweep and crook.

Applied Theory's system will effectively process stems that are not presorted by diameter or butt oriented prior to entering the system.

Table 1

Bucking Optimization Results

Log	Length	Operator	Volume	Value ($)	Optimizer	Volume	Value ($)	Increase Volume (%)	Increase Value (%)
1	45' 11"	16 16 12	236.7	53.69	12 16 16	242.0	53.69	2.23	0.00
2	44' 8"	16 12 14	98.0	18.79	12 16 14	116.0	23.14	18.37	2.31
3	45' 1"	12 12 18	136.7	23.75	16 16 10	143.3	30.63	4.83	2.90
4	44' 3"	12 16 14	224.0	48.85	16 16 10	230.0	51.76	2.68	5.96
5	42' 1"	16 12 12	150.7	30.18	12 12 16	177.4	35.46	17.72	17.50
6	26' 4"	12 10	94.0	18.95	12 10	94.0	18.95	0.00	0.00
7	42' 5"	16 14 10	121.3	25.23	16 12 12	122.0	25.23	0.58	0.00
8	42' 11"	16 12 12	132.0	27.32	12 16 12	133.3	27.45	0.98	0.48
9	32' 11"	16 14	54.0	11.42	14 16	54.0	11.42	0.00	0.00
10	42' 2"	16 16 8	221.3	48.27	12 12 16	254.7	56.02	15.09	16.06
11	36' 7"	12 16 8	102.0	21.18	12 16 8	102.0	21.18	0.00	0.00
12	42' 2"	12 16 12	233.3	51.33	16 12 12	261.3	58.67	12.00	14.30
13	42' 3"	18 18	106.0	10.60	12 12 12	106.0	26.15	0.00	146.70
14	32' 1"	16 16	45.3	8.68	16 16	45.3	8.68	0.00	0.00
15	42' 3"	16 16 8	178.3	38.15	12 16 12	206.0	45.80	15.53	20.05
16	42' 3"	16 16 8	230.0	51.66	16 12 12	252.7	56.10	9.87	8.59
	TOTAL		2363.6	488.05		2540.0	550.33		
	AVERAGE INCREASE							7.46	12.76

Table 2

Board Feed Possible/Shift (100,000 Bd.Ft.)

Machine Center	% of Production	% of Theoretical Maximum	Board Feet Remaining	% of Theoretical Maximum	Board Feet Remaining
Bucking	100	98	98,000	93	93,000
Primary					
Carriage	40	95	37,240	90	33,480
Sharp Chain	60	95	55,860	88	46,872
Total Primary	100		93,100		80,352
Edging					
Board Edgers	35	98	32,240	84	23,623
Cant Edgers	65	98	59,305	86	44,917
Total Edgers	100		91,238		68,540
Trimmer	100	98	89,413	93	63,742

Bucking Maximizer System Description Transverse

Transverse scanning, with photocells on one foot centers, provides a very good representation of the stem's shape and size. Several mechanical conditions will have to be met on the deck to ensure that the log is scanned properly.

The cross transverse deck will require lug chain. This is needed to ensure the stem is travelling in a known manner while scanning. It will be an operator's responsibility to ensure that the stems be even ended before the scanner. With even ending, there is only one foot of uncertain length on one end. This gives a length determination of -0 +12 inches. Without even ending, there is one foot of uncertainty on both ends or a length determination of -0 +24 inches. The mill will be responsible for providing a truss-type scanner bridge to span the deck. Applied Theory will provide specifications of the rigidity required in the truss structure such that scanning is not affected.

Hardware, to include the Hewlett Packard computer and additional components, are the same as, and will be described in, the Longitudinal Bucking discussion.

System Operation

The Applied Theory Longitudinal Bucking Maximizer will have three individual computer systems. The Hewlett Packard master computer receives scan data, calculates the optimum solution and passes it to the PLC. The PLC controls machine sequencing and accepts set commands from the master computer. The Milli, or setworks microprocessor, accepts set information from the PLC and controls the setworks for the saws and a moveable log stop.

A. Scanning

In order for a bucking system of any kind to be effective, the method of looking at the stem is very important. The more information that can be collected, the more accurate the resulting solution will be. We place Opcon 300 scanners on the X and Y axes for diameter measurement. These units take full cross section data on four inch intervals. For length, the combined inputs of a pulse counter and a row of photocells are monitored as the stem travels through the scan zone (Figure 1). This row of photocells consists of pairs of photocells placed one above the other, spaced on two foot intervals along the length of the chain. This high and low placement ensures a reading at each two foot interval, as the stem will not ride under or over the beam as is possible with single cells. By scanning on two axes and plotting the position of each cross section in space, we develop a true picture of the stem including sweep, crook, butt swell and the natural elliptical shape (Figure 2).

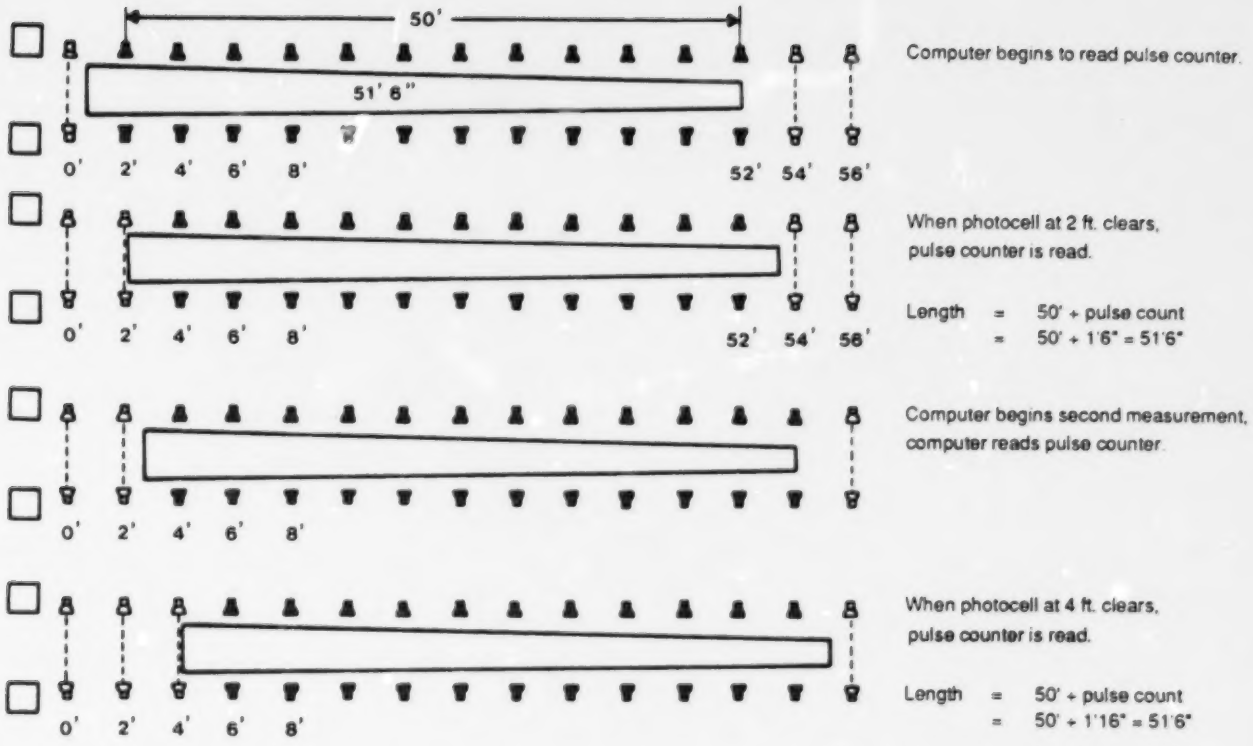

50'
51' 6"
0' 2' 4' 6' 8' 52' 54' 56'
Computer begins to read pulse counter.
When photocell at 2 ft. clears, pulse counter is read.
Length = 50' + pulse count
= 50' + 1'6" = 51'6"
Computer begins second measurement, computer reads pulse counter.
When photocell at 4 ft. clears, pulse counter is read.
Length = 50' + pulse count
= 50' + 1'16" = 51'6"
Process repeats at every photocell for the length of the conveyor.
The shortest length is used since slippage exaggerates the length.

Figure 1 BUCKING-MAXIMIZER
Length Measurement

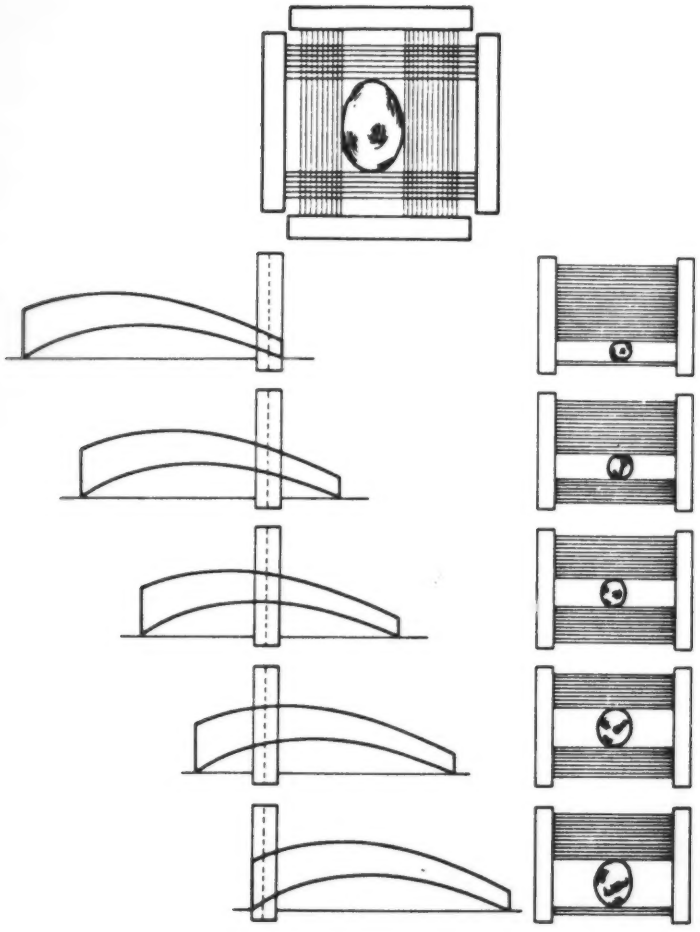


Figure 2 Schematic Representation of "Real Shape" Scanning

B. Real Shape Solutions

With the scan data taken, the computer develops a model of the stem. Traditionally, optimizers take this data and apply some type of pattern to it. Several problems arise. First, pattern solutions assume the stem corresponds to a truncated cone. Sweep is not considered, crook is not considered and neither is the elliptical shape of the cross sections. Our Real Shape Solutions™consider all of these things (Figure 3).

Beginning with the first 8-foot segment in the stem, the Maximizer determines the products that can be sawn. These products are assigned a priority value by the mill and defined in terms of wane allowance and downstream cutting capability. One hundred (100) different boards can be defined. Each of these boards is assigned a value per length. For example, a 2x4, 10 feet long, would have a different value than a 2x4, 16 feet long, given the same wane rules and parameters. It is this comprehensive board table that allows a mill to custom cut. Dimensions and lengths in the greatest demand are given a high value priority. If a large order of a special size is required, the board table can be adjusted immediately so the system can begin "looking" for blocks to fill the order.

Whether this first 8-foot segment is swept, has crook, is round, or elliptical, Real Shape will fit defined boards from the table into the shape. It moves them until it comes up with the most valuable combination. The segment is then assigned a price. The process is repeated for the 10, 12, 14, 16, 18, and 20 inch blocks. It then considers segments beginning at the 2 inch line and moving outward. In this manner, each saw block that can be taken is assigned a value that reflects its true potential regardless of shape.

C. Value Comparisons and Breakdown

Mathematically, there are a limited number of ways to break a stem down. With each possible block assigned a price, it becomes a matter of assembling those of greatest value into available space. The key to this operation is the fact that the computer, in Real Time, is making logical comparisons between the many combinations. This selection process is very important when you consider a swept stem entering the mill. Without guesswork, the Maximizer will calculate whether to buck for maximum length, to cut the swept section out, or to divide the sweep to make two, less-swept blocks.

D. Sequencing

Sequencing of the stem from the bucking infeed, through the scanner, and sawlogs to the small log debarker infeed and the headrig transfer can be the responsibility of Applied Theory. A PLC is supplied for all sequence control. One console is provided for the large log side, the small log side and the bucking system infeed deck.

Once the stem is loaded onto the conveyor, it is critical that it travel smoothly, with movement kept to a minimum. Any unusual movement while the stem is in the scanner will cause improper readings. Once scanned for diameter on two axes, and length, the Hewlett Packard computer calculates the optimum solution. These solutions are stored until the stem passes through the queue and arrives at the saw section. The solution is then displayed to the operator. At that time the operator can override all, or a

Applied Theory

Bucking Maximizer

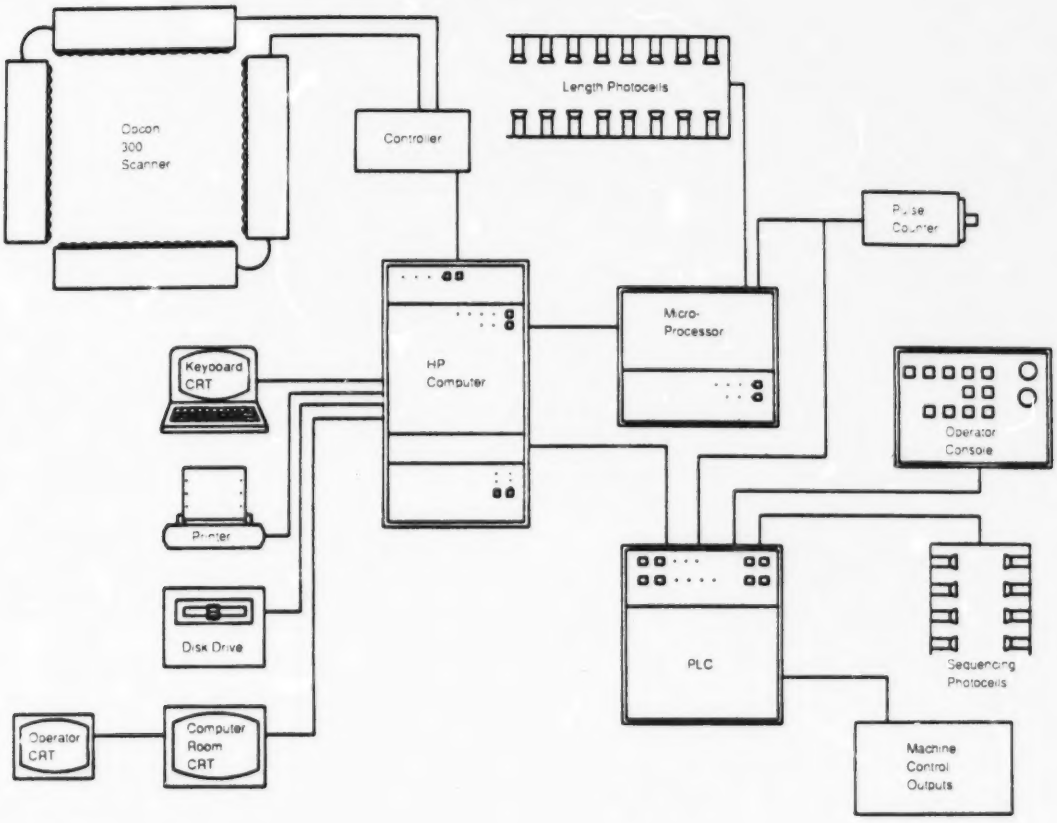


Figure 3 Bucking Maximizer System Configuration

portion of the solution if he desires. If he overrides the entire solution, he can enter a manual set. If he decides to override a portion of the solution, the Bucking Maximizer will take his decision into account and reoptimize the remainder of the stem.

After scanning, large logs will be kicked to the large log side. Small logs will be kicked to a log queue for the small log side.

Large logs consisting of stems 24 to 42 inches small end diameter (SED) and up to maximum length, will be processed by a single cut off saw with cross conveyor log stops, as an example.

Small logs consisting of stems 4 to 24 inches SED and up to maximum length, will be kicked to the multiple saw cut-up station.

After the stems are broken down, the segments are sorted by diameter and sent to the debarker infeed upstream from the Chip-N-Saw, or to the carriage transfer deck. Diameter sorting is accomplished by an Opcon 300 diameter scanner. This allows the mill to change the diameter break at the system console.

Actual stem breakdown on both the large and small log sides will reflect the Real Shape solution calculation for the stem.

The following functions will be under PLC control and will be a part of the sequence control function:

1. Log Deck - Manual operation through infeed console
2. Singulator and Loader - Auto with manual override
3. Log Conveyor - Auto with manual stop
4. Kickers - Auto with manual override
5. Holding Station (large logs) - Auto
6. Large Log Conveyor - Auto with manual stop
7. Large Log Stops - Auto with manual override
8. Large Log Saw - Manual only
9. Transfer to Take Away Log Belt - Auto with manual override
10. Stop-N-Loader to Take Away Log Belt - Auto with manual override
11. Small Log Queue Stops - Auto with manual override
12. Small Log Fence - Auto with preset manual positions
13. Small Log Saws - Auto with preset manual positions
14. Milli - Setworks microprocessor receives sets from PLC
15. Hourglass Roll Lift Plates - Auto up/down with manual
16. Drop to Outfeed - Auto with conveyor manual start stop
17. Sort Scanner - PLC auto control
18. Kick to CNS Deck - Auto
19. Sweep to Overflow Pockets - Auto with operator select
20. Kick to Large Log Deck - Auto

The above is an example of a possible system design. Many variations are available to fit mill parameters.

System Specifications and Features

A. Specifications

Sawlogs generated will be from 8 to 24 feet in nominal 2-foot increments. All sawlogs between 8 and 16 feet will be bucked a minimum of 2-1/2 inches over. Lengths between 16 and 24 feet will be bucked a minimum of 3 inches over. Downstream from the sawing areas, segments will be sorted by diameter to their proper destination. Segments under 9 inches SED will be sorted to the Chip-N-Saw, those over 9 inches SED will be sent to the carriage. This sort function will use an Opcon 300 single axis scanner. The sort diameter can be changed easily at the system console.

1.	Type of System	-	Lineal
2.	Scanners Diameter	-	Opcon 300, dual axis
3.	Scanners Length	-	Dual photocell, pulse generator
4.	Maximum Length	-	61 feet
5.	Maximum Diameter	-	42 inches
6.	Minimum Length	-	8 feet
7.	Minimum Diameter	-	4 inches
8.	Scanner Placement	-	Conveyor break
9.	Solution Type	-	Real Shape Solutions™
10.	Management Reports	-	As Listed

B. Operator's CRT Display

One CRT is provided for the Large Log line and one for the Small Log line.

1. The CRT display will carry the following information:

    a. Headings including time, date, species.
    b. A graphic display of the solution.
    c. Display of cubic volume, scribner, diameter, and length of current stem.

C. Management Reports

Applied Theory furnishes a complete set of management reports. These reports vary in function from brief diagnostic to complete shift summaries. All reports may be requested at any time by entering a simple command at the computer terminal. The reports are as follows:

1. Input Stem Tally Report

    The Input Stem Tally Report prints a table of the counts of each input log by length and diameter, and total of counts, cubic feet and board feet (scribner) of all input logs by length and by diameter.

2. Input Log Length Histogram

The Input Log Length Histogram is a graphic representation of the counts of input logs. Each mark of the histogram represents 2 logs. The mean length and standard deviation are also given at the bottom of the report.

3. Output Sawlog Tally Report

The Output Sawlog Tally Report prints a table of the counts of each output sawlog by length and diameter, and totals of counts, cubic feet and board feet (scribner) of all output sawlogs by length and by diameter.

4. Hourly Product Production Report

The Hourly Product Production Report shows a total for each hour (up to twelve hours of the shift) for piece counts, board feet (scribner), cubic feet and lineal feet produced.

5. Daily Product Production Report

The Daily Product Production Report shows the daily totals from the Hourly Report for each day in the current and previous weeks.

6. Summary Report

A summary of input logs and pieces produced by count, cubic feet, board feet and lineal feet is given in the Summary Report. Also shown are averages for small end diameter, cubic feet, board feet, and lineal feet and the number and percentage of manually entered solutions.

7. Test Solution Program

This is a unique feature of the Bucking Maximizer that allows the mill to simulate distribution. The mill enters a log distribution of lengths, diameters, tapers and grade. The solution program then calculates the optimum solutions and prints the results.

D. Hardware Provided

Hewlett Packard with memory
Time Base Generator
Cabinet
Floppy Disk
Televideo CRT Keyboard
Diagnostic CRT (2)
Microcircuit Card
16 Bit Duplex Card
Dual Channel Port Controller
Powerfail Recovery
Disk Interface
Allen Bradley 2/30 PLC with I/O
Okidata Printer
Slave CRT
High Speed RS232 Interface Cards
Microprocessor Scanner and I/O Controllers

Relay Junction Box
Flexible Coupling
Opcon Detectors
Cables
Opcon 300 Dual Axis Scanner for Real Shape
Opcon 300 Single Axis Scanner for Sorting

Pulse Generator
Opcon Source
Opcon Swivel Mounts

E. Bucking Maximizer Acceptance Test

1. A run of 25 stems will be made. In order to demonstrate true system performance, these stems will not have excessive crook or sweep, and will travel smoothly along the conveyor without slippage, roll or wobble. The system will be shown to have scanned the stems correctly and computed the optimum solutions based on the block prices in the table. The raw scan data and last log calculation data will be printed.

2. A peeler core or other uniform square ended object will be run through the scanner and the scan data printed. The system will be demonstrated to measure the length to within plus or minus 1 inch, and the diameter to within plus or minus .2 inch. After the peeler core test, 25 stems will be run. These stems should have square cut ends and be free of defects such as stump shatter or broken ends. Of these stems, 67 percent will be scanned to an accuracy of plus or minus one inch, 95 percent of the stems will be scanned to an accuracy of plus or minus two inches.

3. Demonstrate that the system responds correctly to one or more changes to the Real Shape parameters using the simulation capabilities built into the system.

4. After a run of 25 stems, the management report will be printed and the tallies demonstrated.

Note: The above items are the key acceptance criteria. Formal procedures for demonstrating conformance will be presented to you for review and approval during the System Design Review.